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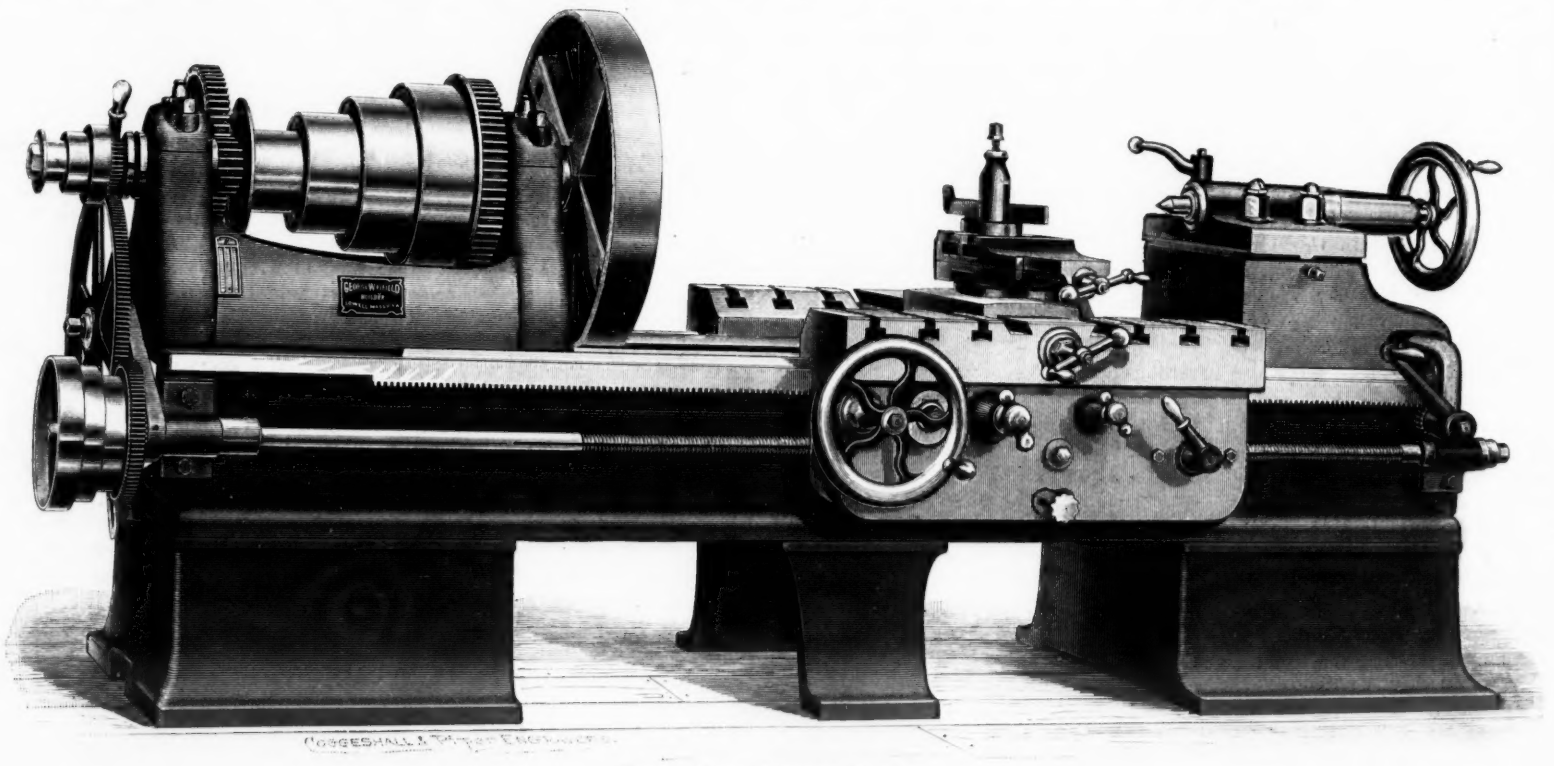
Thirty-inch Engine Lathe.

The accompanying illustration is of a lathe which represents a line of similar ones of varying sizes recently brought out by the Fifield Tool Co., Lowell, Mass. As the engraving indicates, this lathe conforms to standard practice, but is of very heavy proportions, and is about as plain and simple as a lathe can be made, dispensing entirely with attachments, and even with the usual stud in the head-stock; the feed cone and first change gear, being placed directly upon the spindle, and arrangements made for reversing the feed in the apron.

The tool block is easily run off at the back and the carriage is then practically a plain surface with T slots for holding work to be bored or faced. There is a compound rest and automatic cross feed. The lead-screw is splined and serves also as a feed rod for giving motion to the feed worm.

Four bolts secure the foot-stock to the bed and it is moved by rack and pinion.



THIRTY-INCH ENGINE LATHE.

Along the Coast of Kent.

BY W. H. BOOTH.

In previous letters I have referred to the Cinque Ports, those ancient seaports along the coast of Kent and Sussex which were ports long enough before they were granted special privileges as the Cinque Ports in return for certain duties in the way of protecting the country against the "enemy," which in those days was always the particular enemy whose language served to give these ports their particular numerical designation. At a time of a let up from business I first saw the old-fashioned place of Rye which was added to the original five ports, but is now fairly well inland like its neighbor Winchelsea, and I have since visited Deal and Hastings, which are roadsteads rather than ports, while Sandwich is far inland, the original channel of the sea which once made the Isle of Thanet really an island, and up which the Saxons sailed when they first landed here at Ebbesfleet having been quite obliterated, its waters having once washed the walls of Richborough Castle, now a ruin, then a Roman fortress. The ordnance survey maps of this country are fairly complete, but they have one peculiarity in that at certain places they contain no levels and no contour lines, and so for certain purposes actual personal inspection is sometimes necessary to ascertain facts that can usually be approximated from the maps.

As I am not employed in any capacity in the German army I have, of course, no access to the plans which, it is said, the Germans possess of all the English coast—in readiness for contingencies. My only relations to Germany are to pay taxes which go to the support of any German sovereign who happens to be so lucky as to be born a subject of England. I do not know how Americans would like it to be said that England supported her President. I guess they would object to such a president. It is one of the curious anomalies here, however, that though we all object to paying men who have sworn allegiance to a foreign power, such payments seem to continue, and foreigners have the gall to consider us discourteous if in our papers we sneer at the mean spirit that prompts the acceptance of such pauper allowances. However, the fact of the payments is there on the one side and the absence of the map levels on the other, and so I find myself at Dover to ascertain for myself what a foreign power is said to know. Dover is well worth seeing. It lies at the foot of a steep embayment of perpendicular cliffs which seem to be strongly fortified, and are probably much honeycombed by passages and galleries after the manner of Gibraltar. Indeed, one of the most prominent of the cliffs is the well-known Shakspear Cliff which juts out into the sea, and has not a little resemblance to a certain view of Gibraltar. Right under the cliff is a tunnel through which just above sea level the railroad is run alternately upon a low trestle washed by the sea and through a projecting spur of the chalk cliffs which stand up about 400 feet nearly plumb. A little west of Shakspear Cliff, upon a space of flat ground intervening between the cliffs and the sea, are the works of the Channel Tunnel, a little scheme for destroying the insularity of English soil that has done so much to render us safe in the past from foreign aggression, and to abolish which is dear to England's enemies if we are to judge by the very nasty remarks leveled at our "insular position" and "narrow insular modes of thought," nice, polite little inducements on the fox's part to the crow to drop its bit of cheese, as a set-off to which we have the saying of Von Moltke that he had five schemes for invading England but not one for getting out again. The proposed tunnel is to be the way out. I am no old Tory and would draw a line at no work of real good, but I do think that while continental Europe converts itself into an armed camp of five millions of men almost within gunshot of our shores we should be fools to accept their assurances of peaceful intentions.

Of all the Cinque Ports Dover is the only one left that really maintains its position as a port with docks and enclosed harbor and a stone pier, and it appears to have been a place of importance for many centuries, Roman bricks being the material of construction of a building on the Castle Hill, now a church, said once to have been a Roman basilica, which is doubtful. There is also a tower said to be built of a rough volcanic tufa, brought from Italy as ballast in the Roman vessels. The bricks seem to show a hardness and texture of a high class that would appear to indicate a knowledge of brickmaking which has now been lost. Looked at from the sea Dover is backed by huge masses of chalk. Everything is chalk, the soil which covers the surface being but a few inches thick over the white rock, which is very easy to cut and tunnel.

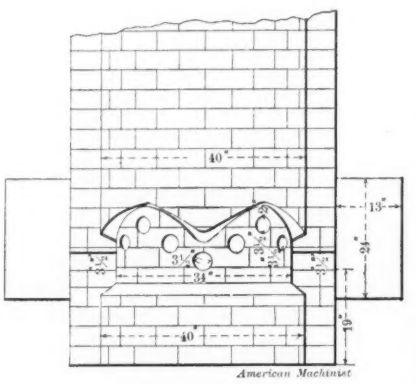
From Dover is the shortest route to France, and it ought to be the best route, but it is in the hands of the Chatham and Dover Railroad, a very moribund line, who place such hindrances in the way of traffic in the shape of slow speed, excessive rates and general discomfort that many passengers now go via the Great Eastern line and Harwich to Antwerp or Rotterdam, and as usual where excessive charges are made, the Dover route blesses neither him who gives nor him who takes financially; a fellow-traveler this morning saying, "This line ought to be put into a receiver's hands, as they would do in America," the occasion being a complete block of traffic from a little derailed car, one wrecking crane being the whole equipment of the line, and that not at hand.

Some lines have a peculiar frequency of derailments as compared with others, and the Chatham line has it badly. Looking at English locomotive practice with a stranger's eye, one is struck with the wide differences in practice, not merely on different lines, but on the same line. There are no leading trucks at all on the Northwestern Railway, but some of the newer engines have lateral movement in the leading axle boxes. On the Midland and the Great Northern, four-wheel leading trucks are common, so are rigid single leading axles. I am told also that the latter company have given up building cars with trucks, as they found them an unnecessary complication and weight on their good roads. On the South-western Railway, on the one hand, are locomotives with coupled leading wheels of large diameter, and on the other hand, engines with also four-coupled wheels and four-wheeled leading trucks of very large

size, the front platform of this class of engine being said to be larger than any yet made, so that, as seen from a distance, the front truck almost seems to be running away with the engine. The express engines of the Brighton line have their leading wheels coupled, and so one might run on naming different practices on the English railroads in respect of locomotives whose duty is substantially the same all over the country, for there would be no difficulty in taking a locomotive of one line and setting it to do the work on any other line. The curious thing is that for freight traffic there is practically one class of engine all over the country. It is only on passenger work that designs vary so widely, and it is hard to see why three or four standard types should not do every sort of duty required. The reason of the differences is that each line has its engineer superintendent, who works to his own idea, and when he dies or goes elsewhere his successor puts his company to the cost of a change in practice. I cannot see why types should not now be more fixed. The most economical engine is known, and it is merely empty talk when one engineer explains away his heavier coal consumption by trying to minimize his brother engineers' engine service. If we look in other directions we find better accord. The makers of the Lancashire boiler all practically follow one plan, and by means of the boiler insurance societies learn when any detail has been improved upon, and they all follow the new detail, so that but for the name-plate and fire-door pattern there is often nothing to distinguish the make of a boiler. Unanimity has not been found to delay improvement, but rather to help it forward, where a universal desire has been felt towards improvement. The locomotive men seem too narrow in their modes of thought to combine in realizing what the stationary boiler men have realized.

At the close of the year we had about one week of frost. During that short time the daily papers *recorded* the explosion of 22 house boilers, causing 7 deaths and serious injuries to 32 other people. The cause was, of course, the freezing up of the circulating pipes, and the marvel is that more such explosions do not happen, for there is really no provision made against frost in this mild climate. Sometimes one finds a safety valve, but it is often placed so far from the boiler that the pipe leading to it might freeze, and the only safe place for the safety valve is directly upon the boiler and in sight and where it can be moved. It should be of the dead-weight description, not of spring type, as the latter are so liable to become fast where neglected. It ought to be the duty of every one who fixes these house boilers to attach a reliable safety valve, for this is far more necessary than it is in case of a steam boiler not liable to have its only outlets stopped by ice.

Unfortunately, the mechanical engineering of a house has got into the hands of the plumber fiend, whose ability extends only to bending soft lead. In this country plumbers are "authorized," but by whom I don't know. Detecting a smell of gas lately, I searched for it—not with a candle—and found it proceeded from a ¼ inch iron pipe which had been broken across at the socket by the authorized one. The broken ends had then been butted together and nailed to the floor beam and a smear of red lead put round the break. This served to explain not only the gas smell, but also why my opposite neighbor's little daughter recently flew down their entrance steps followed by the front door and frame. With all these matters there ought to be some center of authority to whom cases of culpable bad work might be shown, and who should deal with the perpetrator without further trouble on the part of the householder. As matters now stand, the guilty ones go free, because there is no chance for the single individual to proceed against a whole trade, and he pays for the repair of the fault or does it himself. One such rascally plumber had the cheek to threaten me with exposure when I said I would do certain work myself, because I was not an authorized plumber. I never yet employed any one of the fraternity who did not leave behind him work to be done as the result of his clumsiness and incapacity. Working in lead is destructive to the character of a man who takes advantage of its nature. The worker in iron or in wood must either make or mar the piece he operates upon. The lead worker can make if he will, but he never mars, contenting himself with botching, and yet in the few exceptions, how exceedingly neat a really good piece of plumbers' work can be made.



Tuyere Location.

BY HERBERT M. RAMP.

Next to a proper area of tuyeres the most important item in cupola construction is their location. In my article on "Cupola Practice," in AMERICAN MACHINIST, June 21st, will be found the number, size and form of tuyeres necessary to produce the best results, and most economical melting, to which must be added the knowledge of correct location. The utility of two or more rows, or upper tuyeres, as they are sometimes classed, has often been questioned as regards economy; claims have been made that they were failures. Some say there is nothing gained in time, others that there is no saving in fuel, and others still that the economy in time or fuel was overcome by the additional wear of the lining. The cause for this diversity of opinion is we have not arrived at a thorough understanding of tuyere location.

With many the impression is that simple increase in the number of tuyeres distributed in regular rotation over a certain amount of area is all that is necessary to produce a more thorough and uniform blast to the melting point. There is but one melting area in a cupola, and that should be about twelve inches above the tuyeres, though difference in blast pressure will change that considerably.

In placing two or three rows of tuyeres in a cupola, the practice of placing one row directly above another, or the third row above the first, the second interspaced, is an error into which many fall; also placing the upper tuyeres so high that they blow directly on the melting point.

There being but one melting area, there must be but one place in the cupola as regards height, where the most perfect combustion is found, and that area or point should be supplied with blast of the greatest uniformity. If the upper tuyeres are the same size as the lower, the melting point will be raised nearly as much above them as it would be above the lower, were there no upper ones, for the volume of blast would be sufficient to support the melting point, thus little advantage being gained by the extra openings, but there would be the disadvantage of concentrating the blast as far as radial area is concerned. All that will be gained is a deeper and hotter bed, and while it will melt faster than one row, it will require more fuel to support it. It also brings your blast back to the old question of too much concentration of volume, for two tuyeres, one directly above the other, have a similar effect to a perpendicular flat tuyere.

If the upper tuyeres are smaller than the lower ones to such an extent that the blast will not support the melting point, they will force a blast of cold air on the point of fusion, which cannot but be detrimental to economy of fuel and time, for it is forcing a cold blast directly to the place; it takes 12 to 18 inches travel of the blast from the lower tuyeres that support the fire to reach the required temperature. No fire or flame is hottest at the point it receives its draught; in nothing is this so well demonstrated as in a blow pipe, and a cupola is simply an exaggerated blow pipe, as far as the action of heat and blast is concerned.

No matter what size the upper tuyeres may be, they either have some influence in raising the melting point, or by blowing directly on it, decrease the melting area. Iron will not melt directly in front of a tuyere. Six or eight inches in the blast will become so heated that fusion is possible, but if the tuyere blows on the melting point, you form a ring around the outside the melting area that is not a point of fusion, and simply robs the melting area of that many inches. It takes from the vital point the heat to raise the temperature of blast introduced by upper tuyeres.

The wear of lining is also largely due to upper tuyeres, located directly above each other, for when the blast from the upper tuyeres blows on the fire where it is already raised to such an extreme heat, it causes a flame with more force at the actual point of fusion. A sure remedy for a large per cent. of wear on lining, is to contract the lining about 6 or 8 inches from the top of the tuyeres, down to basin, which carries the blast nearer the center and away from the sides.

I have at hand a letter from one of the most practical and experienced foundry men in the country, who uses a cupola with three rows of tuyeres, with the third row smaller, but located directly, or nearly so, above the first. The three rows do not cover a height of over 10 inches. He says: "To be successful you must keep the top row of tuyeres at least 6 inches below the melting point, and keep the upper tuyeres to one-half the size of the lower. If the upper tuyeres wear out larger, the cupola will make dull iron, and rob the lower tuyeres of their part of the work of combustion." He has grasped the correct idea of perfect combustion, as shown, by keeping his rows of tuyeres close together, but in a measure detracted from their true value by placing directly above each other, and shows that keeping the upper ones below the melting point is a necessity.

The question with foundry men to day, is to construct a cupola that will melt with the greatest rapidity and economy, and myriads of different tuyere arrangements have been the outcome, many improving cupolas in a marked degree, but missing the highest possible efficiency to be gained, because more attention is not devoted to the actual principle of blast on fire. After the tuyeres have been distributed around the radial area in proper proportions to the melting area, and of a size sufficient to carry to the center, located in one row, the most uniform and perfect combustion will be obtained, for the fire is fed at every point accessible, and in a uniform manner. To increase the melting capacity beyond the results obtained then resort must be had to other measures, as far as tuyeres and their location is concerned, and the only way that can be accomplished is to increase the melting area. A series of careful experiments brought out the following plan and results:

The accompanying drawing shows a cupola built for rapid melting. It has three rows of tuyeres, as far as height is concerned, but their action on the fire is the same as one, relative to the point of fusion. The melting point follows the curve found by the location of tuyeres, and increases the melting area one-seventh. This assertion is based on the actual increase of iron melted per hour. There is little saving of fuel over one row, it requiring .1 pound of fuel to melt 11.8 pounds of iron on heats of 15 tons, but the remarkable gain in time proves the value of an increased area.

The rows of tuyeres are kept close together, and every one acts direct on the melting area, there are no combinations of different currents of air; all pass the same distance to the point of fusion. Fifteen tons have been melted in 1 hour and 45 minutes from the time the blast was applied till the bottom dropped, and the cupola dropped clean. No punching with bars at tuyeres is necessary; it cleans itself, and during three months' service, I have never found a single tuyere closed ever so slightly. It also demonstrates the fact that three rows do very little as regards economy of fuel. The increased distribution of blast and enlarged melting area increase the capacity per hour, and keep the cupola cleaner and more free from accumulations.

The 40 inch cupola shown is capable of melting from 8 to 9 tons per hour, for five hours, and do it every day with proper management and material.

These are the results I have obtained from the use of two or three rows of tuyeres, and a careful consideration of the subject, and a number of intermediate experiments. It is not necessary to explain or prove that upper tuyeres save little fuel, but when properly located save time.

There are several chemical theories, as to the advantage of upper tuyeres, some requiring tuyeres to be placed above the melting point, but their adoption is so slow I am inclined to look upon them as mere hypotheses.

American Locomotive History.

For many years past it has been known that the chief trouble in obtaining the true locomotive history has always been that the early engines often were built with the same names, and that a number of engines also had their names changed. The subject of the "John Bull" locomotive sent to America in 1831 has been a puzzle to the American engineers; some persons have claimed it for the Mohawk and Hudson road, and others have been equally certain that it went to the Camden and Amboy Railroad. After careful investigation of the difficulty, I have been able to satisfactorily clear up the matter by obtaining proof that there were two engines of this same name in America in 1831. I have now before me the copy of the working drawing from which one "John Bull" was built at Stephenson's works in 1831; this engine was sent to the Mohawk and Hudson Railroad (now a part of the New York Central). It was in every way similar in appearance to the well-known "Samson" class then in use in England, and it had the *square* fire-box. I have also before me another set of working drawings from which, at the same date, the same firm constructed another engine; this was sent to the Camden and Amboy Railroad (now a part of the Pennsylvania system), and when it left Newcastle-on-Tyne it was named "Stevens," but on its arrival in America the name was at once changed to "John Bull." This engine was of the usual Stephenson design, but with one very important exception, namely, that it had a *round* fire-box, this fire box having been specially ordered and insisted upon by Mr. Stevens when he gave the order for the engine. When at the Chicago Exhibition last year I very closely examined the engine shown by the Pennsylvania Company, and since my return home have compared the details with the old working drawings of the engine ordered by and named "Stevens," 1831, and there is most convincing proof that the "John Bull" at Chicago was the real old engine with the round fire-box which was supplied by Stephenson and Co. to the Camden and Amboy Railroad in 1831.—*Clement E. Stretton, C. E., in Engineering.*

W. Maddocks, M. E., of Parsons, Kansas, chief draftsman Motive Power Department of the Missouri, Kansas & Texas Railway, properly called the M., K. & T. line, and W. H. Brehm, general foreman of the M., K. & T. shops located in the same city, have been spending a fortnight in the East in connection with the finishing up and shipment of five consolidated locomotives built for that road by the Baldwin Works. Both gentlemen are enthusiastic over the

workmanship shown in the engines. The M., K. & T. has recently opened and equipped new shops at Smithville, Texas, the Niles Tool Works furnishing most of the machine tools. They think the Western railroads are showing more disposition to improve their equipment than has been the case during the past year.

Comparison of Different Formulæ for Dimensions of Parts of Steam Engines.—IV.

By WILLIAM KENT, M. E.

Crosshead Pin or Wrist Pin.—Whitham says the bearing surface for the wrist pin is found by the formula for crank-pin design. Seaton says the diameter at the middle must, of course, be sufficient to withstand the bending action, and generally from this cause ample surface is provided for good working; but in any case the area, calculated by multiplying the diameter of the journal by its length, should be such that the pressure does not exceed 1,200 pounds per square inch, taking the maximum *load on the piston* as the total pressure on it.

For small engines with the gudgeon shrunk into the jaws of the connecting rod, and working in brasses fitted into a recess in the piston rod end and secured by a wrought-iron cap and two bolts, Seaton gives:

The diameter of the gudgeon = 1.25 × diameter of piston rod.

The length of the gudgeon = 1.4 × diameter of piston rod.

If the pressure on the section, as calculated by multiplying length by diameter, exceeds 1,200 pounds per square inch, this length should be increased.

J. B. Stanwood, in his "Ready Reference" book, gives for length of crosshead pin 0.25 to 0.3 diameter of piston, and diameter = 0.18 to 0.2 diameter of piston. Since he gives for diameter of piston rod 0.14 to 0.17 diameter of piston, his dimensions for diameter and length of crosshead pin are about 1.25 and 1.8 diameter of piston rod respectively. Taking the maximum allowable pressure at 1,200 pounds per square inch and making the length of the crosshead pin = $\frac{4}{3}$ of its diameter, we have for our engines:

Diam. of piston, in.	10	30	50
Max. load on piston, lbs.	7,854	70 686	196,350
Diam. of crosshead pin, in	2.22	6.66	11.09
Length of crosshead pin, in	2.96	8.88	14.79
Stanwood's rule gives diam., in	1 8 to 2	5.4 to 6	9 0 to 10
Stanwood's rule gives length, in	2.5 to 3	7.5 to 9	12 5 to 15
Stanwood's largest dimensions give pressure per sq. in., lbs.	1,309	1,329	1,309

which pressures are greater than the maximum allowed by Seaton.

The Shaft—Twisting Resistance.—The general formula for torsion is,

$$T = \frac{M \times S}{Y}$$

in which T is the torsional moment (generally expressed in inch pounds), M is the polar moment of inertia of the section considered, S is the shearing resistance of the material, and Y is the distance of the remotest fiber from the neutral axis.

For round sections $M = \frac{1}{2}\pi r^4$, or $1.5708 r^4$, in which r is the radius, and $Y = r$, whence $T = 1.5708 r^3 S$, or $T = \frac{\pi}{16} d^3 S = .19635 d^3 S$, in which d = diameter in inches, and S the shearing resistance of the material in pounds per square inch. Transposing, $d = \sqrt[3]{\frac{5.1 T}{S}}$.

If a constant force P were applied to the crank pin tangentially to its path, the work done per minute would be,

$$P \times L \times \frac{2\pi}{12} \times R = 33{,}000 \times I.H.P.,$$

in which L = length of crank in inches, and R = revolutions per minute, and the mean twisting moment $T = \frac{I.H.P.}{R} \times 63{,}025$.

Therefore,

$$d = \sqrt[3]{\frac{5.1 T}{S}} = \sqrt[3]{\frac{321.427 I.H.P.}{R S}}.$$

This may take the form

$$d = \sqrt[3]{\frac{I.H.P.}{R}} \times F, \text{ or}$$

$$d = a \sqrt[3]{\frac{I.H.P.}{R}},$$

in which F and a are factors that depend on the strength of the material and on the factor of safety. Taking S at 45,000 pounds per square inch for wrought-iron, and at 60,000 for steel, we have, for simple twisting by a uniform tangential force,

Factor of safety =	5	6	8	10		5	6	8	10
Iron, F =	35.7	42.8	57.1	71.4	a =	3.3	3.5	3.85	4.15
Steel, F =	26.8	32.1	42.8	53.5	a =	3.0	3.18	3.5	3.77

Unwin, taking for safe working strength of wrought-iron 9,000 pounds, steel 13,500 pounds, and cast-iron 4,500 pounds, gives, a = 3.294 for wrought-iron, 2.877 for steel, and 4.15 for cast-iron. Thurston, for cranks of axles of wrought-iron, gives, a = 4.15 or more.

Seaton says: For wrought-iron, f, the safe strain per square inch, should not exceed 9,000 pounds, and when the shafts are more than 10 inches diameter, 8,000 pounds. Steel, when made from the ingot and of good materials, will admit of a stress of 12,000 pounds for small shafts, and 10,000 pounds for those above 10 inches diameter. If forged from *scrap* mild steel f should not exceed 9,000 pounds for the large shafts, and 10,500 for small ones. The difference in the allowance between large and small shafts is to compensate for the defective material observable in the heart of large shafting, owing to the hammering failing to affect it.

The formula $d = a \sqrt[3]{\frac{I.H.P.}{R}}$ assumes the tangential force to be uniform, and that it is the only acting force. For engines, in which the tangential force varies with the angle between the crank and the connecting rod, and with the variation in steam pressure in the cylinder, and also is influenced by the inertia of the reciprocating parts, and in which also the shaft may be subjected to bending as well as torsion, the factor a must be increased, to provide for the maximum tangential force and for bending.

Seaton gives the following table showing the relation between the maximum and mean twisting moments of engines working under various conditions, the momentum of the moving parts being neglected, which is allowable:

Description of Engine.	Steam Cut-off at	Max. Twist. Divided by Mean Twist.	Cube Root of the Ratio.
Single-crank expansive	0.2	2.625	1.38
" "	0.4	2.125	1.29
" "	0.6	1.835	1.22
" "	0.8	1.698	1.20
Two-cylinder expansive, cranks at 90°	0.2	1.616	1.17
" " "	0.3	1.415	1.12
" " "	0.4	1.298	1.09
" " "	0.5	1.256	1.08
" " "	0.6	1.270	1.08
" " "	0.7	1.329	1.10
" " "	0.8	1.357	1.11
Three-cylinder compound, cranks 120°, H. P. opposite one another, and H. P. midway,	H. P. 0.5, L. P. 0.66	1.40	1.12
" " " L. P. cranks	" "	1.26	1.08

Seaton also gives the following rules for ordinary practice for ordinary two-cylinder marine engines: Diameter of the tunnel shafts $= \sqrt[3]{\frac{I.H.P.}{R}} \times F$, or

$$a \sqrt[3]{\frac{I.H.P.}{R}}.$$

Compound engines, cranks at right angles—

Boiler pressure 70 pounds, rate of expansion, 6 to 7, F = 70, a = 4.12.

Boiler pressure 80 pounds, rate of expansion 7 to 8, F = 72, a = 4.16.

Boiler pressure 90 pounds, rate of expansion 8 to 9, F = 75, a = 4.22.

Triple compound, three cranks at 120 degrees—

Boiler pressure 150 pounds, rate of expansion 10 to 12, F = 62, a = 3.96.

Boiler pressure 160 pounds, rate of expansion 11 to 13, F = 64, a = 4.

Boiler pressure 170 pounds, rate of expansion 12 to 15, F = 67, a = 4.06.

Expansive engines, cranks at right angles, and the rate of expansion 5, boiler pressure 60 pounds, F = 90, a = 4.48.

Single crank compound engines, pressure 80 pounds, F = 96, a = 4.58.

For the engines we are considering it will be a very liberal allowance for ratio of maximum to mean twisting moment if we take it as equal to the ratio of the maximum to the mean pressure on the piston. The factor a, then, in the formula for diameter of the shaft will be multiplied by the cube root of this ratio, or $\sqrt[3]{\frac{100}{42}} = 1.34$, $\sqrt[3]{\frac{100}{3.28}} = 1.45$, and $\sqrt[3]{\frac{100}{30}} = 1.49$ for the 10, 30 and 50 inch engines respectively. Taking a = 3.5, which corresponds to a shearing strength of 60,000 and a factor of safety of 8 for steel, or to 45,000 and a factor of 6 for iron, we have for the new coefficient a_1 in the formula $d_1 = a_1 \sqrt[3]{\frac{I.H.P.}{R}}$, the values 4.69, 5.08 and 5.22, from which we obtain the diameters of shafts of the six engines as follows:

Engine No.	1	2	3	4	5	6
Diam. of cyl.	10		30		50	
Horse-power I. H. P.	50		450		1250	
Revs. per min. R.	250	125	130	65	90	45
Diam. of shaft $d = a_1 \sqrt[3]{\frac{I.H.P.}{R}}$	2.74	3.46	7.67	9.70	12.55	15.82

These diameters are calculated for twisting only. When the shaft is also subjected to bending strain the calculation must be modified as below:

Engine No.	1	2	3	4	5	6
Diam. of cyl., inches	10		30		50	
Horse power	50		450		1250	
Revs per min	250	125	130	65	90	45
Maximum pressure on piston P	7,854		70,686		196,350	
Leverage, dist. bet. centers of crank pin and shaft bearing $\frac{1}{16} l + 2.25 d = L$ ins	6.32	7.94	22.20	26.00	36.80	42.25
Bending moment, $P L = B$ inch lbs.	49,637	62,361	1,569,322	1,837,836	7,225,680	8,295,788
Twisting moment T =	47,124	94,248	1,060,290	2,120,580	4,713,400	9,424,800
Equivalent twisting moment $T_1 = B + \sqrt{B^2 + T^2}$ (approx.)	118,000	175,000	3,463,000	4,647,000	15,840,000	20,850,000

Resistance to Bending.—The strength of a circular section shaft to resist bending is one half of that to resist twisting. If B is the bending moment in inch pounds, and d the diameter of the shaft in inches,

$$B = \frac{\pi d^3}{32} \times f; \text{ and } d = \sqrt[3]{\frac{B}{f} \times 10.2}.$$

f is the safe strain per square inch of the material of which the shaft is composed, and its value may be taken as given above for twisting (Seaton).

Equivalent Twisting Moment.—When a shaft is subject to both twisting and bending simultaneously, the combined strain on any section of it may be measured by calculating what is called the *equivalent twisting moment*, that is, the two strains are so combined as to be treated as a twisting strain only of the same magnitude, and the size of shaft calculated accordingly. Rankine gave the following solution of the combined action of the two strains:

If T = the twisting moment, and B = the bending moment on a section of a shaft, then the equivalent twisting moment $T_1 = B + \sqrt{B^2 + T^2}$.

Seaton says: Crank shafts are subject always to twisting, bending, and shearing strains; the latter are so small compared with the former that they are usually neglected directly, but allowed for indirectly by means of the factor f.

The two principal strains vary throughout the revolution, and the maximum equivalent twisting moment can only be obtained accurately by a series of calculations of bending and twisting moments taken at fixed intervals, and from them constructing a curve of strains.

Considering the engines of our examples to have overhung cranks, the maximum bending moment resulting from the thrust of the connecting rod on the crank pin will take place when the engine is passing its centers (neglecting the effect of the inertia of the reciprocating parts), and it will be the product of the total pressure on the piston by the distance between two parallel lines passing through the centers of the crank pin and of the shaft bearing, at right angles to their axes, which distance is equal to ½ length of crank pin bearing + length of hub + ½ length of shaft bearing + any clearance that may be allowed between the crank and the two bearings. For our six engines we may take this distance as equal to ½ length of crank pin + thickness of crank arm + 1.5 × the diameter of the shaft as already found by the calculation for twisting. The calculation of diameter is then as below:

Having already found the diameters on the assumption that the shafts were subjected to a twisting moment T only, we may find the diameter for resisting combined bending and twisting by multiplying the diameters already found by the cube roots of the ratio $T_1 \div T$, or

	1.40	1.27	1.46	1.34	1.64	1.36
Giving corrected diameters d_1 =	3.84	4.39	11.35	12.99	20.58	21.52

By plotting these results, using the diameters of the cylinders for abscissas and diameters of the shafts for ordinates, we find that for the long stroke engines the results lie almost in a straight line expressed by the formula diameter of shaft = .43 × diameter of cylinder; for the short stroke engines the line is slightly curved, but does not diverge far from a straight line whose equation is diameter of shaft = .4 diameter of cylinder. Using these two formulas the diameters of the shafts will be

4.0 4.3 12.0 12.9 20.0 21.5.

J. B. Stanwood, in *Engineering*, June 12, 1891, gives dimensions of shafts of Corliss engines in American practice for cylinders 10 to 30 in diameter. The diameters range from $4\frac{15}{16}$ to $14\frac{15}{16}$, following precisely the equation diameter of shaft = ½ diameter of cylinder — $\frac{1}{16}$ inch.

Fly Wheel Shafts.—Thus far we have considered the shaft as resisting the force of torsion and the bending moment produced by the pressure on the crank-pin. In the case of fly-wheel engines the shaft on the opposite side of the bearing from the crank-pin has to be designed with reference to the bending moment caused by the weight of the fly wheel, the weight of the shaft itself, and the strain of the belt. For engines in which there is an outboard bearing, the weight of fly wheel and shaft being

supported by two bearings, the point of the shaft at which the bending moment is a maximum may be taken as the point midway between the two bearings, or at the middle of the fly wheel hub, and the amount of the moment is the product of the weight supported by one of the bearings into the distance from the center of that bearing to the middle point of the shaft. The shaft is thus to be treated as a beam supported at the ends and loaded in the middle. In the case of an overhung fly wheel, the shaft having only one bearing, the point of maximum moment should be taken as the middle of the bearing, and its amount is very nearly the product of half the weight of the fly wheel and the shaft into the distance from the middle of its hub from the middle of the bearing. The bending moment should be calculated and combined with the twisting moment as above shown, to obtain the equivalent twisting moment, and the diameter necessary at the point of maximum moment calculated therefrom.

In the case of our six engines we assume that the weights of the fly wheels, together with the shaft, are double the weight of fly wheel rim obtained from the formula $W = 785{,}400 \frac{I.\ H.\ P.}{R^3\ D^2}$ (given under Fly Wheels); that the shaft is supported by an outboard bearing, the distance between the two bearings being 2½, 5 and 10 feet for the 10-inch, 30 inch and 50-inch engines respectively. The diameters of the fly wheels are taken such that their rim velocity will be a little less than 6,000 feet per minute.

Engine No.	1	2	3	4	5	6
Diam. of cyl., inches	10		30		50	
Diam. of fly wheel, ft	7.5	15	14.5	29	21	42
Revs. per min	250	125	130	65	90	45
Half wt. of fly wheel, lbs	268	536	5,968	11,936	26,470	52,940
Lever arm for max. moment, in.	15	15	30	30	60	60
Maximum bending moment, inch lbs	4,020	8,040	179,040	358,080	1,588,200	3,176,400

As these are very much less than the bending moments calculated from the pressures on the crank pin, the diameters already found are sufficient for the diameter of the shaft at the fly wheel hub.

In the case of engines with heavy band fly wheels and with long fly wheel shafts it is of the utmost importance to calculate the diameter of the shaft with reference to the bending moment due to the weight of the fly wheel and the shaft.

B. H. Coffey (*Power*, October, 1892) gives the formula for combined bending and twisting resistance, $T_1 = .196\ d^3\ S$, in which $T_1 = B + \sqrt{B^2 + T^2}$, T being the *maximum*, not the mean twisting moment, and finds empirical working values for .196 S as below.

He says: Four points should be considered in determining this value. First, the nature of the material; second, the manner of applying the loads, with shock or otherwise; third, the ratio of the bending moment to the torsional moment. The bending moment in a revolving shaft produces reversed strains in the material, which tend to rupture it. Fourth, the size of the section. Inch for inch, large sections are weaker than small ones. He puts the dividing line between large and small sections at 10 inches, and gives the following safe values of $S \times .196$ for steel, wrought-iron, and cast iron, for these conditions.

Heavy Quarter-turn Belt Drive.

BY JAMES F. HOBART.

Two or three years ago, I noted with a good deal of interest, the attempts made by an engineer to transmit around an angle of 90 degrees, without gears, the power carried by a 3½ inch shaft. A 48-inch belt was required to handle the work at the speed given to the shaft.

The first attempt was made as shown by Fig. 1, which represents the ordinary pair of guide pulleys necessary to carry a belt "around a corner." On small belts this device works very well, and is in use in thousands of places, but with the wide belt (48 inches) trouble commenced almost at the start.

The belt did not last. It gave out at the edges, then the fastenings let go, and a cement splice was necessary every time the belt needed taking up, which was very often. Finally the belt bill became so large that the wide belt was thrown away, and the belt drive shown by Fig. 2 put in its place.

But trouble did not cease with the change. The four 12-inch belts could never be made to run well on the large pulley, the belts would climb one upon another, and once let two of the belts lap edges ever so little, and the lapping action increased until one of the belts ran fairly and fully on top of another upon the 48-inch pulley.

Sometimes three of the belts would get in a heap. Two begin to lap upon opposite edges of another. The immediate result of the climbing tendency was to destroy the belts. Just as soon as the edge of one belt lapped upon another, the outer belt was practically running upon a pulley of greater diameter than was the belt upon which it lapped. More feet per minute of belt was thus delivered to the driven pulley, which, being keyed fast to a shaft, with three others, could not run any faster than the others, therefore something had to slip.

The slipping was between the belts and the pulleys, and consumed considerable power. Even when the belts were new and straight, and ran well beside each other upon the 48 inch pulley, there was some slip owing to the difference in size of the four driven pulleys. Unless great care is taken, and special pulleys turned for the purpose, four 48 inch pulleys cannot well be picked up in any stock of pulleys, which will take belts without slip from a single wide pulley, or from four narrow pulleys.

The persistence with which two, or even three of the belts would climb upon one another—and stay there—led the engineer to experiment a little in that direction. He

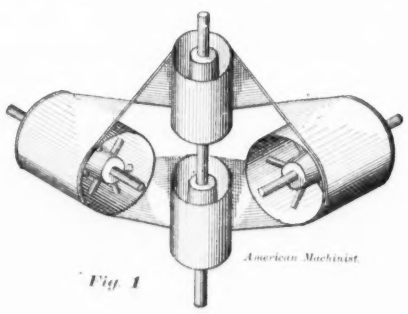


Fig. 1

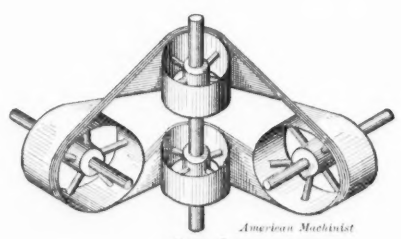


Fig. 3.

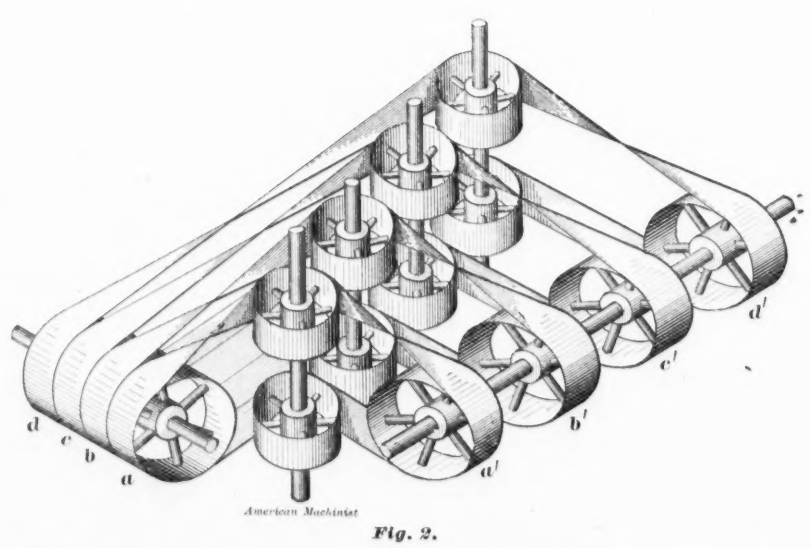


Fig. 2.

put the belts a and b, both upon pulleys $a\ a'$, and the other two belts both upon pulleys c, c', cutting down belts b and d to fit, the result was gratifying. The belts drove nicely, and did the work with much less squeaking than when they ran separately upon four pulleys.

For the sake of experiment, three of the belts were placed upon pulleys $a\ a'$, one belt being superimposed upon another. The ideas of the engineer were fully met by the behavior of the belts in their new position. All of the squeaking and slipping was done away with, and a friction card from the machinery running empty, showed a considerable decrease of power absorbed, as compared with what was used up with belts on two of the pulleys. It was neglected, in the proper place, to state that the friction card with two belts showed less power absorbed than when four were doing the driving. The three belts upon a single pair of pulleys showed a corresponding degree less of power absorbed.

Another gain was observable. With the wide belt drive, Fig. 1, the transmission often became overloaded, and the belt after running halfway off of one of the pulleys would squeak and smoke until the overload was removed, a loss of speed of the driven shafting being noticeable during the period of squeaking. With the two belts run double (on pulleys a and c, Fig. 2), there was less loss of speed during the periods of overload, and still less when the three belts were on a single pair of pulleys (Fig. 3).

The engineer entertains serious doubts regarding the strength of pulleys a', b', c' and d', and their capacity for carrying the entire power transmitted. He is having made a single pair of heavy pulleys which are to displace the 13 pulleys shown by Fig. 2. Eight bearings will also be dispensed with. It is expected that the three belts "in series," to use an electrical term, will drive from 10 to 25 per cent. more than four belts "in multiple," Fig. 2.

Went Without Help.

The steamship "Arcadia," passing to the northward of Scotland, recently picked up off the Orkneys a three masted British ship and towed her into Kirkwall. The name of the vessel was the "Cubana." She had sailed from Newfoundland in October, 1892, with a cargo of copper and ore for Swansea, but encountered a succession of violent storms, which so knocked her about that the crew despaired of saving her, and got themselves carried off by a passing ship. That was on November 14th, and the "Cubana" was not expected to float until another sunrise, but somehow or other the ship took charge of herself, and made wonderful weather of it, although November and December were bad months on the Atlantic.

A fortnight after she was abandoned the Cunard steamship "Aurania" sighted her with her rigging wrecked, but the hull as good as ever, in the same parallel of latitude, but seven degrees more to the eastward. On December 9th she had driven three more degrees easterly and was seen and boarded by the Norwegian bark "Alma," which brought away some papers. On December 11th the steamship "Floridan" passed her another couple of degrees to the eastward, drifting a little northerly. Three days later the "Catalonia" steamship sighted her, still near the Banks, but then she was caught by the northeasterly set of the Gulf Stream, so that the next report of her was on January 10, 1893, when she was seen again well over to the Scotch coast with nothing of her spars standing except the mizzenmast.

For thirty days did that abandoned ship drive before the winds and currents of the Atlantic with her main hatch open and no rudder, being brought at last into harbor. What became of her afterward is not stated.

It was the proud and constant boast of Admiral Rous that, in his naval days, he had brought a Queen's ship across the Atlantic without a rudder. The iron bark "Cubana" certainly deserved to be re-equipped and remanned; for, although she did not make her port of destination, she brought her copper ore, without a hand to steer her, across the Atlantic at its wildest, and safely into harbor.—*The Million.*

LETTERS FROM PRACTICAL MEN.

Small Bore Indicators.

Editor American Machinist:

Some years ago I made a good many calculations for the "Pneumatic Gun Carriage Company," for the purpose of finding the proper size of cylinders and pistons for taking up the recoil of heavy guns by the compression of air, calculating back from the weight and velocity of the shot leaving the gun, and the weight of gun and attachments. I had nothing but theory to guide me, so I recommended making a mount for a small gun 3.2 inches diameter, with cylinders, as I thought, about right for that size, intending to take indicator cards when the gun was fired.

At my suggestion the Crosby Gauge Co. made a fine steel instrument, with a plunger .18 inch diameter, fitting in the hole below the cylinder. This gives an area .025 square inch, which is $\frac{1}{20}$ that of the .50 inch area piston, consequently, scale of the ordinary spring is multiplied by 20, and the instrument and its springs remain good for lower pressures. I took several diagrams, and found that my theory was not badly out, and so went on with the calculations for larger guns with confidence. In all this I did not consider that I had done anything very wonderful, but the Ordnance Bureau U. S. N., seeing the successful working of the instrument (a thing which they had declared impossible up to that time), in the hands of the Gun Carriage Company, sent in haste to the Crosby Co. for two instruments exactly like the one they had seen, and did considerable testing on their recoil cylinders. In their annual report they took great credit to themselves as the first to demonstrate the work done in a recoil check, and the service papers were loaded with praises of the "cleverness" of our scientific navy officers. My diagrams were very smooth and satisfactory, starting with a base line of 500 pounds per square inch, and running up a curve to about 5,000. They gave the high or adiabatic curve, showing that the whole heat of compression was retained within the air, for that instant, yet the metal of the cylinder and the indicator did not show the slightest signs of warming.

It seems to me eminently proper and correct, to use small bore indicators as our pressures get high. The leakage is reduced, and the strain, also, which is sometimes so great as to blow off the tops.

The reduction of this strain, I regard as a great point in favor of the chances for accurate registration by the pencil.

WILLIAM H. HARRISON.

Fly Wheel Disasters.

Editor American Machinist:

The large number of fly wheel accidents within the last two or three years ought to be sufficient to cause all engineers to be fully alert and constantly on guard, especially where large wheels are used, to prevent, if possible, such disasters, that so endanger their own lives as well as the many others that are necessarily exposed upon such occasions, besides preventing great destruction of valuable property that such accidents naturally bring about.

Considerable has been both said and written concerning these accidents, and the agitation should be continued that the cause may be more fully understood.

There has been more definite information published concerning the wheel burst in the large cotton mill in the Merrimack Valley on August 10th than of any others I have seen an account of, and it is such information that should be published that it may be of use to others in preventing such accidents.

One of the accounts, as given by Mr. Bullock in the AMERICAN MACHINIST of August 23d, is very complete as to the cause. He says that the gear was secured to the spindle with a taper pin. Now such work as that cannot be too severely condemned.

If anyone had been killed in that accident the average coroner's jury would no doubt have blamed no one but God Almighty. The idea of securing a gear on the lower end of an upright shaft with a taper pin, the head of the pin necessarily downward, and that, too, on so important a piece of machinery as a steam engine governor, is nothing short of criminal carelessness.

And another account of this accident, accompanied with a diagram, showing among other things the position of the engineer at the time to be within a few feet of the left-hand engine, and his claim that he knew nothing of it until the wheel broke, is not without its moral, for such a claim is not admissible should he deny that the breaking of the wheel woke him up. And he may be truly thankful that he got out of that engine room with his life, for I agree with Mr. Bullock when he doubts a man's ability to have prevented the accident, such prevention depending upon closing alternately two screw stem throttle valves.

Had he been between the engines, he could have prevented the accident by throwing up the detaching levers, but it is customary for the average man to become rattled upon such occasions and think of the right thing at the wrong time, it not being customary to handle the detaching levers until after the throttles are closed. This force of habit might have cost him his life had he been between the engines.

The conclusion is now forced upon us that the ordinary screw stem throttle valve is a nuisance and should be discarded and relegated into history, where it should have been long ago, and a balance valve used in its stead; it is preferable to the detaching lever for quick work in case of an accident; and is also preferable to a throttle valve for every-day use.

There is no doubt but the governors have become inoperative through some manner of neglect, and have been the cause of most, if not quite all, of the fly wheel accidents.

If a jack pulley breaks, or for any other cause the load is suddenly thrown off of an engine, the governor should control the engine within a safe rim speed of the wheel, and will do so if the governor is in good working order, but it will not do so unless it is in good working order.

There are several ways in which a governor may be neglected.

The regulator dash-pot is a source of much trouble, bad running, and danger if there is either too much or not enough vent in the dash, or if the oil used in the pot is too heavy it will hold the governor to the extent that the engine will race badly, and, on the other hand, if the oil is too light the dancing of the governor is liable to throw the belt off, and the bearing in the top of the column that supports the running gear of the governor, if not kept clean and carefully oiled, is liable to break or slip the belt off.

A little gritty dust in the surrounding atmosphere will work into the bearing formed between the sleeve and the spindle and choke the governor down if not properly oiled.

About 10 years ago I was employed near a Corliss engine that ran away from this latter cause. There was no one in the room at the time, and there is no knowing what speed the engine attained, but it was sufficient, so that the vibration of the cam rod caused the hook to part company with the wrist plate, thus stopping all of the valves and likewise the engine. No damage resulted further than the stopping of the mill until the governor could be got to work again, from the fact that the fly wheel was of small diameter and a solid casting.

About 15 years ago I was within 200 feet of a slide valve engine that ran away, caused by the breaking of the governor belt. The governor was of the Judson throttle type with automatic stop attachment, which failed to do its duty from the fact that it had been neglected until it was so gummed up with dirt and oil that it was impossible to make it work; the breaking of the wheel destroyed considerable property but no lives were lost.

S. A. SMITH.

Office and Shop Stationery.

Editor American Machinist:

The subject of office and shop stationery, while of minor importance, is, nevertheless, one worthy of consideration, and regarding which some information may be forthcoming in these columns, if experiences are related. Just how much room exists for improvement can best be shown by some of the establishments in which there has never been an attempt at systematic arrangement or production in the case of the numerous blanks required in conducting the business.

My experience has been something as follows: When the matter of stationery (which term is intended to cover all printed forms) was first taken in hand, there existed a great variety of blanks, some on one grade of paper, some on another, although intended for exactly similar uses. Some were machine ruled in light lines, in the case of others the ruling being set up in the original form, avoiding thereby the extra cost of independent ruling. Styles of type were printed without limit, electrotypes existed of some forms, but not of all, while sizes of sheets or blanks were almost as numerous as the forms themselves.

The first step was to make a collection of all existing forms. These were grouped roughly according to character, and were gummed, by their left-hand edges, successively in a scrap-book. Each separate form was then given a distinctive consecutive number, which was marked upon it thus, F 25.

It happened that at the time this matter was taken in hand there was under consideration a new order system requiring a number of new forms. Accordingly, standard sizes and standard type were adopted. The sizes running in multiples of 3 inches by 6 inches, thus, 3x6, 6x6, 6x9, 9x12, 12x 18. Up to date no reason has been shown to cause regret as to these sizes. A perfectly plain Gothic type—the so called block letter—was also chosen, and the upper case or capitals used for all headings and principal words, while the lower case or small letters were employed for the less important portions. The letters were thus always clear and distinct, permitting of no misunderstanding. A typical form is here presented.

Each new form as made up was designated by its number, and when the blanks were printed, this was followed by the number ordered and the date. Thus, F 57—5 M—6-19-93, indicating that five thousand copies were ordered June 19, 1893. Upon the page of the scrap book opposite this form was noted the name of the printer and the price, not only for press work and paper, but also for electrotyping and blocking whenever there was a charge for either of these items. Electrotypes were made in all cases, where it was evident that the form was permanent, and that money would eventually be saved by the operation.

Change in a form—no matter how slight—also changed its form number, so that there could be no opportunity for confusion. The electrotypes were also designated by their form numbers, and it was therefore a simple matter to order in any quantity without further description or possibility of mistake. The gradually accumulating lists of prices paid have been of great service in guarding against overcharges, and in asking and accepting bids for work. As rapidly as possible old forms requiring changes are being reset in the Gothic type.

As a result of the introduction of this system there is gradually coming to be greater economy exercised in all of the printing. The uniformity in sheet sizes makes it possible to run several different forms on the same sheet with the opportunity for economically cutting them therefrom, and furthermore greatly simplifies the filing of the filled blanks, for they will all fold to 3 inches by 6 inches, if desired

Variety in colors of paper for different purposes aids in sorting, and avoids confusion. The scrap book, and the orderly arrangement of the stationery closet simplify greatly the matter of keeping up the stock, and remove to a considerable degree the chance of running entirely out of a given form before it is noticed.

Just what arrangement is best to adopt in a given establishment must, of course, be determined by the existing conditions, but it is certain that the adoption of a method similar to outline above cannot fail to result in both convenience and economy.

WALTER B. SNOW.

F 62—5M—3-23-92

STOCK MEMORANDUM.

B. F. STURTEVANT CO., Jamaica Plain, ... 189...

Please Deliver to Bearer, for.....

To be used on Order No .....

NUMBER OF Pieces.	ARTICLE.	Weight.	To be Filled in by Office. Price.	Amount.

No article will be delivered from stock room without this form of memo. Foreman.
This blank to be used on one order only.

Treatment for a Drowned Watch.

Editor American Machinist:

Although a "jeweler" by trade I have for years been a regular reader of the AMERICAN MACHINIST, missing none of the good things always to be found in it.

In your issue of August 30th Mr. James F. Hobart recommends "sousing" a drowned watch in alcohol. Such treatment would certainly remove the water, but, unless done by a jeweler, would be certain to loosen the pallet stones and roller jewel, which are set in shellac, thereby deranging the escapement and making the readjustment a rather costly job, especially if the jewels drop out and are lost, which could easily happen, as they are too small to be readily observed.

I have frequently, in the past 20 years, treated watches drowned in *fresh* water, brought to me at various intervals after immersion, and have always practiced placing them in tumbler of kerosene oil until I could give them attention.

I have found this entirely efficacious in stopping any further tendency to rust for several days at least.

I consider this a better plan for the owner of the watch as, at most, he would lose the main spring, from being so entirely inclosed that the oil could not reach it, and displace the water; however, unless having been too long submerged, the water would, for the same reason, have little effect on that part.

As for the sulphuric acid I should be as much afraid of damage from the fumes, being confined in a box, as of the water.

After his, or any treatment, the watch would most certainly "need to be oiled before running satisfactorily," but before being oiled it would need to be taken down and thoroughly cleaned and otherwise looked after.

CHAS. WEBER.

Hackettstown, N. J.

The West System of Tests.

Editor American Machinist:

As one interested in the establishment of a reliable system of tests for cast-iron, I wish to reply to the article in your issue of August 30th, entitled "Plans and Methods Necessary for Obtaining Comparative Physical Tests of Cast-iron," by T. D. West. After reviewing Mr. Whitney's labors on the matter of expansion during the moment of solidification, Mr. West says, "They all prove that casting test bars between yokes or rigid flask ends is wrong, as they do not permit the test bars to have a natural action; . . . . it is sufficient to know that it will not permit the free action which the nature of the iron demands." Practically this point amounts to nothing; it need not be taken into account, for the reason that we cannot point to a single instance in which its consideration has been of benefit, either one way or the other. There cannot be an instant of uniform solidification throughout the bar, when it is cooling, because the parts adjacent to the sand must form a point of solidification in themselves while the interior is fluid. Neither can there be a point of uniform expansion in a bar gated in the middle and molded on the side, because the iron at the intersection of the gate and casting is hottest, and therefore attains to the point of solidification after the latter has occurred in the halves of the bar, from the center towards the ends.

In the yoke method of casting test bars with two gates, the bar is divided into three distinct divisions, that is to say, there are

three parts of the bar that arrive at the point of solidification, while there are two parts, *i. e.*, in front of the gates, that do not arrive at it at the same time. Hence any expansion of the parts of the casting that had attained solidification would react on and compress the soft centers, and tend to raise the metal in the gate above, consequently there is no uniform moment of expansion in the bar, and there is also, for this reason, no stress or strain on the bar or the yokes.

Another point in this connection, is the fact that on the instant the bar is filled with metal the chill, from its action on the iron, has driven the graphite carbon back from the face of the end of the bar. Consequently, on the principle that the less silicon and graphite present, the quicker the iron sets or chills, a chill or cooling has caused a lateral contraction from the face of the chill on approximately $\frac{1}{2}$ inch, on each end of the bar, before the point of solidification has been reached in the balance. Therefore it will be evident that as there is no uniform point of solidification there can be no similar point of expansion, and consequently there will be no stress on the bar or the yoke as indicated by Mr. West.

The next point Mr. West makes is, "To know what an iron will chill, it is necessary that the chill and casting should remain in close contact until both are cold to handle."

In this Mr. West is in error, for the reason that if we want to know the chill of an iron, we want its chill in every-day practice, and not what it will chill under certain conditions. In choosing an iron or making a mixture for chill castings, the chill the iron will give in the work is what we want to arrive at, and not what it will do if the work is cast so that the iron and chill will remain in contact, as this is impracticable on 95 per cent. of chill castings. In the system of tests originated by W. J. Keep, of Detroit, Mich., the chill is taken in the natural way, and is an exact indication of what the chill of the iron would be in chill rolls, roller shells, cams, stamp shoes, crusher jaws and heads, sheaves, car-wheels, etc., and a large number of other castings not to mind at this moment. It will be evident, therefore, that for practical purposes Mr. West's ideas on chilling are not deserving of serious consideration.

The size and form of test bar recommended by Mr. West would not, so far as the writer knows, apply to any form of casting except, possibly, rolls and sash weights. About 98 per cent. of the castings are cast horizontally, therefore, it is advisable to have our test bars cast in the same manner. The fact that the round bar is cast on end would condemn it, as there would be a greater crystallization of the iron in its center than there would be in a square bar of equal cross-section. This crystallization would consequently weaken it, and prove its indicated strength less than the castings made of the same iron. Furthermore, the fact that the bars are cast on end would be no criterion to go by, as about all our castings are cast on their sides. Therefore we want the strength of the iron as we use it, and not its strength under conditions that are not practiced. In casting a test bar on end there are unequal pressures on the mold, and while, theoretically, the lower part would be, and probably is, densest, in practice it is heaviest on account of the lack of a reliable manner of molding it. To overcome this, Mr. West would have the bottom of the bar pattern smaller than the upper end. It apparently does not occur to him that it is just as difficult to ram the mold so that the bottom would swell the correct amount, as it is to ram it without having it swell at all. There is no such uncertainty connected with the manner of making test bars used by Mr. Keep, for nothing out of the ordinary practice is necessary.

The writer's experience in testing square bars cast on end, 1-inch section, 14 inches long, and 12 inches between supports, has been that the bar will break usually past the center, towards the end of bar cast up. This is caused principally from the lower part of the bar being heavier than the upper, not taking the theoretical view of the different densities of the metal into consideration.

As to the turned bar, in arriving at what the strength of the casting will be, the skin chill it receives from the mold must not be lost sight of, therefore, the turned bar would not indicate the strength of the casting unless the latter was turned or finished completely. As the writer has mentioned previously, we want the strength of the iron as we use it and not its natural strength.

Mr. West says: "One using this system will soon discover it will be very rare to obtain a test bar that is not perfectly solid. This in itself is worth an adoption of the system in preference to present practice, for it only needs a review of the remarks after tests to show the comparatively few sound test bars that are obtained in proportion to the number that are made." In this we find another illustration of the weakness of this system, in that special pains are taken to secure a sound test bar, when the same pains are not taken with the casting. It is, therefore, not a reliable index of the strength of the casting and consequently cannot be compared with the average tests cast in the same manner as the casting.

In the fluidity strips we have another example of the impracticability of Mr. West's system. The strips give the life of the iron rising vertically, with two test bars in the mold, and that is all they do give. The iron in them is prevented rising naturally on account of the test bars, the latter, from the amount of iron they take, retard the rise of the metal in the strips, and the results are consequently no indication of how fluid the iron is, but, rather, only an index of its fluidity under the conditions. Much better results would be obtained if the strips were cast on a separate gate. But supposing they were, what would they indicate? There is no thin class of castings that are cast from the bottom or in the manner shown in the test bar; everything either drops or is poured horizontally in light work. Therefore, an iron that runs molds cast horizontally, will run them if dropped or poured down, because the former is the more difficult to cast successfully, hence we want to know what an iron will do under those conditions only.

The manner of measuring contraction would be more practical if a better method was used to insure the tips always being a stated distance apart. The gauge may be set into the mold with great care and the sand tip punched with the same; but when we come to measure contraction in two, three and four places of decimals, this plan, it will appear, cannot be compared with the accuracy of the yoke method.

Anyone acquainted with chilling an iron can see that the method of obtaining the chill by Mr. West is defective. The iron passing through the chill at the bottom will wash out and prevent chilling at this point until the mold is full. This fact makes it impossible on many classes of chilled work to gate the castings on the bottom, as the iron in motion near the face of the chill will wash or cut the depth of the chill away.

The method of measuring shrinkage used by Mr. West is equally impracticable. The cavities in the end of the test bars can be made larger or smaller, according to the manner in which the iron is poured into them. This, of course, can be regulated to some extent, but the wave motion of the metal due to the pressure cannot be overcome by this method. In pouring down the gate, the drop of the metal, together with the different heights of it in the gate and bars, cause the flow of the metal to rise higher in the bars than in the gate, and in receding it will leave a larger cavity than would naturally be the case if the bars were poured from the top. Therefore, as the wave flow of the metal cannot be avoided, the moment it reaches the iron ends of the flask it becomes frozen and will always show more shrinkage than is present in the iron.

In conclusion, it will be apparent that the system of tests presented or outlined by Mr. West contains many errors that do not recommend it to those in search of a reliable system of tests for cast-iron. Mr. West has aimed at the ideal rather than the practical. He wants the natural strength, the natural chill, the natural expansion and the natural shrinkage, points all of which bear no relation to practical results only as they could be estimated relative to what is shown in practice.

ALEX. CAIRNS.

Detroit, Mich.

Fraudulent Testing.

Editor American Machinist:

I regret that my letter on the above subject, in your issue of August 2d, did not contain a sufficiently explicit and elementary treatment of it, so that it would be made entirely clear to those who, like your correspondent "C.," have some acquaintance with the subject of acceleration. In that case the letter of "C.," in your issue of August 30th, would probably not have been written. My statements and formula did, as your correspondent states, have reference to the acceleration of the straining mechanism, and not of the weighing mechanism, and were correct as far as they went, but I should have gone further and considered the case of possible acceleration of the weighing mechanism, as "C." has done, and drawn some conclusions from that case. This I will now endeavor to do.

To simplify matters, suppose that the machine is of the old fashioned kind in which weights are added on a hanger at the outer end of the last or lightest lever of the series of levers that constitute the weighing mechanism, that a constant force of 4,000 pounds is applied at the specimen, which is balanced by a $\frac{1}{2}$ pound weight at the outer end of the lever, the leverage being 8,000 to 1, as in the case considered by "C." Suppose this $\frac{1}{2}$ pound weight to be at rest, floating at the middle point between the upper and lower stops which keep its movement within narrow limits. Suppose the weighing levers are three in number, each 20 inches in length on the longer arm, and 1 inch on the shorter arm, which will give a total leverage of 8,000 to 1, and that their whole weight, including that of the gripping attachment connecting the short end of the first, or heaviest lever, is 500 pounds. To compute the force required to give this mass an acceleration about the three fulcrums is quite a complicated problem, involving the equivalent moment of inertia, and the radius of gyration or radius of the center of inertia of the whole system, which depends upon the forms of the levers, but we can gain an idea of the approximate amount of the force by considering the velocities of the ends of the three separate levers. Suppose the outer end of the last lever rises 1 inch in one twelfth of a second, or at the rate of 1 foot per second. Its inner end and the outer end of the second lever, to which it is connected by a link, move at a velocity of one-twentieth of a foot per second; the inner end of the second lever and outer end of the first move $\frac{1}{400}$ foot per second, and the inner end of the first lever, with the connection to the test piece, moves $\frac{1}{8000}$ foot per second. As the weight of the inner half of the first lever is heavier than all the rest of the system put together, we may without serious error consider that the whole weight of this lever is 450 pounds, and that its radius of gyration is 10 inches from its fulcrum. We may also consider that the second lever weighs 50 pounds, and that its resistance to acceleration is equivalent to that of a weight 20 times as great, or 1,000 pounds, applied 10 inches from the fulcrum of the first lever; also that the weight of the third lever is 10 pounds, and its resistance to acceleration is equivalent to that of a weight 400 times as great, or 4,000 pounds, at a point 10 inches distant from the fulcrum of the first lever. The total equivalent inertia is then that of 5,450 pounds at the extremity of the radius of gyration of the first lever. The upward velocity of this point is 10 times as great as that of the inner end of the test piece, or $\frac{1}{800}$ foot per second. Applying the formula force = mass × acceleration, and letting the time = 1 second, we have $m\ v = \frac{w}{g} v = \frac{5,450}{32.16} \times \frac{1}{800} = 0.21$ pound, or a little over one-fifth of a pound, instead of 4,000 pounds, which seems to be the result reached by your correspondent "C." for an assumed velocity of 1 inch per second, or only one-twelfth of the velocity that I have assumed.

The error in this part of "C.'s" computation is in his assumption that the whole of the weighing mechanism, or 500 pounds, is accelerated 1 inch per second, while the fact is that it is only the outer end of the smaller beam, which is very light, that receives anything like a rapid acceleration, and that the heavy portion of it next the test specimen receives almost no acceleration at all.

If the force required to produce acceleration is taken at the short end of the heavy lever, instead of its radius of gyration, the equivalent weight at that point is 10 times as great, or 54,500 pounds, but the velocity is only one-tenth as great, so that the result, or $w\ v \div g$, is the same, or 0.21 pound.

Coming down from theory to practical experience we find that the amount of force actually needed to accelerate the weighing parts of a good 50,000 pound testing machine, of the platform scale type, with screw-pulling apparatus such as Olsen's or Riehle's, to a sufficient extent to make the outer end of the scale beam jump up and down, is merely a slight pressure with the little finger, and this pressure overcomes not only the inertia of the moving parts, but the friction of the knife edges.

In the last paragraph of "C.'s" communication he says that the acceleration of the straining mechanism "is transmitted to balance weight through levers." This is not the case when the material is stretching, as it does, unless it is a brittle material, just before rupture.

I have shown in my previous letter that the force required to accelerate the straining mechanism is not communicated to the weighing apparatus at all; the only force weighed being that which goes through the specimen, and not that which is absorbed in giving velocity to any part of the straining mechanism.

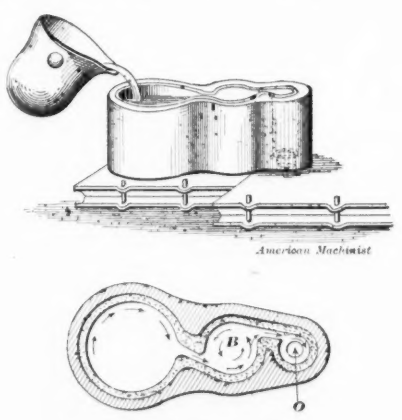
In "C.'s" letter he assumes that any force that may be required to accelerate the weighing apparatus is registered by it as an addition to the load on the specimen. As I understand his last paragraph, he figures that this false registration might be as much as 4,000 pounds. In his previous paragraph he says: "In order to prevent this upward acceleration the balance weight is kept at such a point that not only the load carried by the specimen but also the inertia of moving levers due to increment of weight is balanced."

In the above calculation of the force required at the test specimen to produce acceleration of the weighing mechanism, I have said nothing in regard to the question whether this force, small as I have shown it to be, is added, as a false registration, to the load required at the end of the last lever to balance the pull on the specimen when the parts are at rest; but, in fact, there is no such false registration. The parts being at rest, the poise weight balances the static load on the specimen, the poise can only move upward by the application of an additional load on the specimen itself. During the time, a fraction of a second, in which the beam is rising beyond its middle point, the poise is registering falsely; that is, the load on the specimen is greater than the weight of the poise, or the position of the sliding balance weight indicates, by the force of inertia required to give acceleration to the whole of the weighing mechanism, the work done by which force does not reach the poise at all (except the insignificant amount necessary to accelerate the poise itself) but is absorbed in the acceleration of the mechanism. When the outer end of the beam reaches its upper stop, motion ceases, there can then be no question of acceleration, and the poise is registering falsely, but in the same direction as before; that is, it

indicates less than the actual pull on the specimen. If, however, the poise weight is increased to such an extent that the beam moves downwards, then during the time of such downward motion, the poise weight is too great, being that required to balance the pull on the specimen, plus that required to overcome the inertia of the weighing mechanism. In the case considered, if the downward motion were as rapid as 1 inch in one-twelfth second, practically a sudden drop, the error might be as great as a fifth of a pound in the total registration of weight of several thousand pounds. If the beam is allowed to remain at rest on the lower stop then there is, of course, "fraudulent testing," for the poise weight is greater than that required to balance the pull on the specimen, but this case will only occur through gross carelessness or intentional fraud.

It thus appears that the acceleration of neither the straining apparatus nor of the weighing apparatus can cause any false registration by the testing machine, except an entirely insignificant amount, and that this amount, when due to the rising of the weighing beam, caused by rapid motion of the pulling mechanism, is against the specimen, that is, it causes the registration to be less than the actual pull transmitted through the specimen. WM. KENT.

[Mr. Kent's mathematics are, no doubt, correct, but while we do not care to go into a detailed discussion of the matter, we believe they are wrongly applied. It has been demonstrated many times by actual trial, that a testing machine of the type under discussion will register much more when the load is applied rapidly than when applied slowly. The Congressional Investigating Committee were shown this at the Carnegie works, and the machine was actually made to indicate about 4,000 pounds excess stress upon a standard specimen, simply by running the machine very rapidly. We believe this is due to acceleration, or, if preferred, to the resistance due to inertia of the mass of the weighing mechanism, and that nothing yet brought forward by Mr. Kent disproves this.—ED.]



A Foundry Device.

Editor American Machinist:

There is often a question in your paper of foundry practice, and perhaps the following information will interest your readers:

To prevent blow holes in castings, and to prevent also the impurities which are found in pig-iron, we make use of an arrangement which has been devised by Mr. Van Riet, and patented in all countries.

Considering a foundry ladle filled with melted metal, you will notice impurities on its surface, and if you remove them other impurities will rise from the metal to the surface. These impurities are the cause of blow holes on the upper part of castings. Therefore, when a very smooth surface is required on a casting, this piece will have to be cast upside down. With Mr. Van Riet's system this is no longer necessary, as these impurities do not enter the mold.

We herewith have the pleasure to hand you a sketch of the apparatus, which is very simple and of cast-iron, lined with earth by dipping it in a pap* of earth.

As you will see by the arrows, the metal has a motion of rotation, and owing to centrifugal force all impurities are separated from the metal before entering by the holes *O* in the mold. At *B* a great porous mass will be collected.

Col O. P. French, an American passing through our city, has seen the thing in operation in our works, and has been convinced of its efficiency.

Your countrymen having always obligingly answered all questions which we have been asking them, we shall be very pleased in return to supply them with any further information they may want, and which will be in our power to give. H. BOLLINCKX.

Bruxelles, Belgium.

[* Clay mixed thin with water.—ED.]

A Simple Mode of Tempering.

Editor American Machinist:

I have noticed at different times in your paper articles upon tempering, and as the subject is quite interesting to me, thought, perhaps, that a little experience of mine might not be uninteresting to others.

It is generally supposed that for tempering most kinds of tools a bath or quenching material other than water is desirable, especially if these tools be of the finer sort, such as milling cutters, reamers, dies, etc., and my experience, though small, tends to verify this in so far as that water cannot always be certainly depended upon. A milling cutter hardened in water may crack and it may come out sound; it may warp or may come out straight as a string; apparently, it seems to me, as the steel or water sees fit. I have taken two cutters from the same bar, of practically the same size and shape, heated them as near evenly and uniformly as possible, quenched them in water of a uniform temperature, and yet one came out cracked and the other sound. So, from this and many like experiences, I have come to believe that water is not always to be trusted, but something which I think can be trusted, which at least with me has given excellent results, is common lard oil. I have hardened milling cutters in this which came out perfectly and uniformly hard, with a thin, black scale, in most cases easily removable with a little turpentine and waste, and which left the steel of a greyish white color and without the least sign of check or crack. And these were special cutters, too, being all different in size and shape, and nearly all having fillets, ogees, etc., cut into them. After cutting tool steel continuously for three days these cutters showed scarcely any signs of wear, and were not at all brittle, as was proved by the operator "catching" the teeth several times. In short, they have given excellent results in every respect.

The oil used was the ordinary No. 2, or second grade lard oil, and the temperature all the way from 30 degrees up to 70 or 80, as some of the tempering was done in the winter (the oil being in a cold room) and some in the summer. The main point is to have plenty of it. A small amount is apt to take fire and cause trouble unless the article tempered is very small. But it is always better to have a large quantity, at least 5 or 10 gallons, even for small pieces, and, of course, for very large work one would need a much larger quantity, the object being always to keep the oil as near as possible at a uniform temperature.

The only care requisite in dipping even a large piece is to immerse it as quickly as possible, in no case halting at the surface, and after getting it well into the middle of the body of oil, moving it rapidly about until cool.

This way of tempering or hardening may be old to some mechanics, but I had never heard of it before, in a measure blundering into it by accident, and feel, therefore, that it may be worth writing a few lines about for the benefit of those who, like myself up to a year or so ago, may never have heard of it.

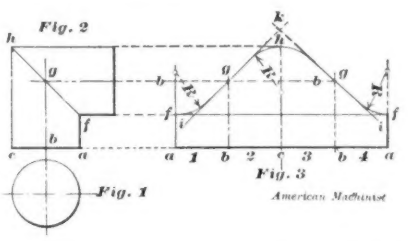
The steels used were "Crescent Extra," and the best and second grades of "Black Diamond." ANTI KNOW ALL.

It is always so easy for a man to see how his neighbor, who lives across the street, might improve the appearance of his place! —*Somerville Journal.*

An Elbow Pattern.

BY GEORGE GUNTZ.

The following is a simple rule-of-thumb method by which to lay out the pattern for a square elbow; that is, a right angle elbow in two pieces, and while it is only a cut-and-try method it will be found to approximate so closely to a correct method, that any trimming after it is formed up is altogether unnecessary.



It will also be found, where absolute accuracy is not essential, to be a much quicker method, and is especially adapted to shops where the conveniences for pattern laying out are only the floor, a steel square, a straight edge, and a pair of compasses. In the illustrations Fig. 1 is a plan showing the shape of the pipe. Fig. 2 is a side view of the elbow.

These two figures are not at all essential to laying out the pattern by this method, but are introduced here more to show where the different points are to be taken from. Further on I will explain the method without these two figures. Fig. 3 is the pattern.

In laying out the pattern by this method, lay off the circumference and divide into four equal spaces, 1, 2, 3, 4, Fig. 3, and draw division lines *a*, *b*, *c*, laying off any lap you may want outside of *a* at each end; set off the length of the throat *a f*, Fig. 2, on *a f*, Fig. 3; the distance *b g*, Fig 2, on *b g*, Fig. 3, and the distance *c h*, Fig. 2, on *c h*, Fig. 3; then through the points *g* on *b g*, Fig. 3, draw the lines *i k* at an angle of 45 degrees; then with a radius *R* of about four fifths of a space *a b*, or *b c*, strike an arc through the point *h*, which will be tangent to the lines *i k;* if this radius does not cut through the point *h* and be tangent to the lines as shown, it should be changed until it does.

Having found the correct radius for the center part use it to strike the throat curves through the points *f* and tangent to the lines *i k* as before; then after adding any further laps that may be required the pattern is complete.

As previously stated I will now explain the method for laying out the pattern with out the use of the plan and elevation referring only to Fig. 3, lay off the circumference and divide it into four equal spaces as before, set off the height of the throat on *a f*, as may be required; then set off the diameter upward from *f* to *h*, divide this diameter into two equal spaces, and draw a horizontal line *l* through the center, and where this line intersects the line *b g*, the points *g* will be established; then proceed as before by drawing the lines *i h* through the points *g* at an angle of 45 degrees, and taking the same radius strike the curves, add the laps and the pattern is complete.

The Laws of Mechanics.

The *Sewing Machine Times* reprints from our columns "A Mechanic's" letter on "A Neglected Study," and comments editorially upon it as follows:

The letter of "Mechanic," on our first page, taken from the AMERICAN MACHINIST, may be read with profit by our salesmen as well as mechanics. If it induces any who are not already familiar with the elementary studies of natural philosophy ot take them up, they will find in the "neglected study" a knowledge that will give them new ideas about the goods they are handling. Many of the sewing machines that have been on the market have shown in their construction a lack, or a disregard, of knowledge of some of the first laws of natural philosophy. In the design of cams, proportions of levers, bearings, springs, etc., the lack of this knowledge has been apparent to those who understood the laws that govern the application of force.

These mistakes have been felt by the builders, and by salesmen, in the lack of popularity of their machines; by the purchasers, in unsatisfactory working; and by repairers and adjusters when in the course of use the machines needed their services.

More conspicuous instances have been seen in the appliances of outside inventors and manufacturers which were intended to improve the regular machines. Many of these have been mechanical abortions—as foolish as the perpetual motion schemes. Among these were the weighted wheels, the springs and levers applied to treadles to increase the power, and the so-called spring motors.

The salesman who understands the philosophy of the movements of a machine can talk more intelligently about it and makes none of the absurd statements that are sometimes made, and which are likely to repel rather than attract a well-informed customer.

Natural philosophy is an interesting study, and to a person of scientific mind is most fascinating. We specially commend this extract from "Mechanic's" letter:

"There are a few fundamental principles, which if known, the reason for thousands of things, to a reasoning mind, becomes as 'transparent as glass,' and not only this, but very interesting."

An Idea of Herr Mannesmann's.

A favorite idea of the eminent German engineer, Reinhard Mannesmann, some account of whose achievements we gave in our issue of May 17th, was that there should be a combination of agriculture with the mechanical and other industries, and he is said to have "demanded for every workman a certain portion of free land, upon which he could grow the most necessary fruits and vegetables, and thus be able to support life in himself and family when crises came." There is, of course, no doubt that if every working man could easily secure and retain possession of sufficient land to support himself and family upon in time of necessity it would solve many of the most vexatious problems connected with carrying on industrial operations, and would remove much of the bitterness of wage contests by simply assuring at least the possibility of making a living and thus relieving both employers and society from the charge of imposing "starvation wages." Any workman who then thought wages were approaching the starvation point, could quit and employ himself upon his land, and a sufficient number would probably always do this to keep wages at a life-supporting point at least.

But by the present arrangement, as we have before pointed out, the land speculator accompanies, if he does not precede the establishment of, industries, and by his operations largely prevents working men from owning their own homes, and, also, often, in his blind greed, seriously interferes with the extension of industries, the establishment of which has perhaps made his fortune. In Germany, where, of course, Herr Mannesmann studied the matter, population is much denser than here, where we have as yet only about 14 inhabitants to the square mile as against 106 per square mile in Europe, showing that any scarcity of land here, for a long while to come, must be purely an artificial scarcity.

In Detroit this relation between distress and artificial barriers to the use of land has been recently brought into prominence by Mayor Pingree, who, as a result of an investigation into the matter, called attention to the fact that while there were thousands of distressed people—working men and their families—within the city, there were at the same time about 5,000 acres of idle land within the city limits, held out of use for speculative purposes; land enough, in other words, to entirely relieve the distress if only made accessible for use. He proposed that the owners of this land should allow it to be cultivated by those out of employment, free of charge, with what success we are unable to say.

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High Wages and Low Cost of Production.

As our readers know, this journal has always maintained that in manufacturing operations, low wages and low cost of production were not only not synonymous, but that, on the contrary, those goods, of a given quality, produced at lowest cost, usually come from the factories and shops paying the highest wages. Years ago "Chordal" spoke in these columns of "Those short sighted employers who think they can make money out of the machine business, if they can only get men at low enough wages," and offered to bet a 50-cent summer hat with each of them that there was more profit in a job done by three-dollar men, than in the same job done by one-dollar men, other things being equal.

Many others have treated, more or less fully, this question of the relation between rate of day wages and cost of production, with the result that it is becoming now pretty well understood that in considering the cost of a proposed production the labor cost per unit of finished work is the important thing to be considered; not the rate of wages per day.

In a new book by Lujo Brentano, entitled "Hours and Wages," translated by Mrs. William Arnold, and imported by Scribners, we find perhaps the fullest recent treatment of this important question, the author having evidently taken great pains to study deeply into the subject, with the result that he confirms the now established fact that well paid, intelligent and ambitious labor is, in the long run and in the main, more economical in all countries than illy paid, and therefore poorly nourished, ignorant and unambitious labor.

A century and a half ago it was held by economists that low wages were necessary to keep people at work; and it was accepted as an axiom that, "the better off people are the less they work." Adam Smith was the first great economist who taught the opposite, and he argued on both physiological and psychological grounds that "high wages are equivalent to great production." In his "Wealth of Nations" he writes that the wages of labor are the encouragement of industry, and shows how "a plentiful subsistence increases the bodily strength of the laborer, and the comfortable hope of bettering his condition animates him to exert that strength to the utmost." Citing practical examples of this he pointed out that in England, where wages were relatively high, workmen were more active, diligent and expeditious than in Scotland or Ireland, where wages were relatively low. Afterwards Benjamin Franklin declared "that low pay is by no means equivalent to cheap work, but rather the contrary," and 50 years ago the movement for shorter hours was helped forward by the writings of McCulloch, who emphasized the importance of high wages as a stimulus and incentive to work and to patriotism; the work of McCulloch being supplemented by that of Senior, who studied the question abroad, and declared that production in France was more costly than in England in spite of the lower wages paid in France. He declared, as a result of study of the matter in the factories of England and France, that an Englishman's production was about double that of a Frenchman's.

Brassey, the English contractor who built railroads all over Europe, found that for such work as he employed in his operations, it made little or no difference what the daily rate of wages might be in the country where the work was to be done, the labor cost of the finished road was practically constant, under otherwise similar conditions; though it is to be remarked here that the engineers and other skilled men employed by Brassey were probably the same in all countries, and that his methods were practically the same in all countries. Had his entire force of employes been found in the country in which for the time being he was carrying on work, it is more than likely he would have found that the rate of wages, instead of being a matter of indifference to him would have been one of importance; the higher wages being by far the most economical.

With the introduction of machinery into England it was held that because "the machine does the work and the operator only looks on," hours of labor could be lengthened; and, in some cases, operatives actually did work as much as 16 and even 20 hours a day, until a general struggle for shorter hours, espoused by England's most famous statesmen, resulted in legislative restriction of hours of labor. Macaulay, speaking of the effect of low wages and long hours of labor, said, "The natural difference between Campania and Spitzbergen is trifling, when compared with the difference between a country inhabited by men full of bodily and mental vigor, and a country inhabited by men sunk in bodily and mental decrepitude." A president of the English Board of Trade wrote, "It is the long hours of foreign people which protect us from their competition."

Mr. Brentano, who, as a result of his study of the question, is convinced of the great advantages of high wages and short hours of labor, does not, of course, claim that raising a man's wages will necessarily result in an immediate decreased cost of production by him, but that when wages rise, there gradually comes discrimination, and the law of nature may destroy or reduce to a lower plane the incompetent; but the survivals are the best, and a general result is an elevation of the whole standard of life.

It does not, of course, follow from what has been said above that a machine shop, for instance, in which wages average $3 a day, will necessarily make more money than one in which the wages average $2, but it does follow that other things being equal, and provided always that the management is what it should be, that shop which has a selected corps of men, devoted, ambitious, energetic and skillful, will make the most money, and such corps can be gathered and retained only by means of higher wages and better treatment generally than the same men can secure elsewhere.

It also means that every citizen who throws his influence in favor of higher wages and improved conditions generally for working people, is doing good thereby, not only to the direct beneficiaries, but for his country and humanity.

We have, on different occasions, advised our readers of small means to look closely into the matter before investing their savings in so-called national building and loan associations instead of a local association. We do not charge dishonesty against national associations, but we believe that in high salaries and in "taking care" of a favored few the assets of the association disappear in a manner not possible with the local association. And now it appears to be decided, in some States at least, that a national association can levy assessments on their stockholders at will, and that the officials have just about the same power as a trust to make things go to their liking. Workingmen with no more than a few dollars a month to invest have succeeded very well, indeed, by investing it in local associations, where they have every opportunity to know how it is being managed, and a voice in the management. When big fish and little fish swim in the same pond the little ones are likely to get swallowed.

A Good Deal of Influence.

The question of the influence of long pipes to a steam engine indicator will not down. Mr. Willis has given us several communications on the subject, and Mr. Fred Lowe, of *Power*, has taken up the subject. There is not a shadow of doubt as to the honesty of both these investigators, yet what they find out is about as much in opposition as can be. Mr. Willis finds that a few feet, more or less, of pipe, does not seem to influence the character of the diagram. But Mr. Lowe shows that there is a wonderful influence wrought by the length of pipe. There is evidently more in the whole matter than has come to light. Mr. Lowe did not use the particular conformation of pipe that was used by Mr. Willis. What difference this may have made we cannot say. Added length of pipe makes more clearance, but there is little difference in diagrams from engines with different degrees of clearance, except what can be accounted for by a simple consideration of the principles involved. But Mr. Lowe's experiments would seem to show that the added clearance, as a simple matter of clearance, had but little to do with the matter.

It is no more than a wonderful small amount of steam or pressure, whatever it may be called, that lifts the piston of the indicator the distance it must be lifted for its purpose. And at the worst it is a big port that affords the lifting pressure. We are not prejudiced the least in the matter, and in the end shall try and give the exact conclusions.

It seems almost incredible that there should be, in a small section of this country, the loss of nearly a thousand lives from forest fires. A fire in a large city, with the loss of a half dozen lives, stirs up the whole country, but in this Western fire villages were wiped out, and whole families died the most horrible of deaths. There are no words with which to fitly describe the horrors of this forest fire.

It is not entirely assuring, the feeling that there is no certainty as to the quality of the plates with which many of our war ships are protected, but we do not believe in the plan recommended of taking them off and shooting them to pieces to determine their qualities. It will be costly, and perhaps the ones with which they are replaced will be no better. No one knows with certainty that they are not good, and this element of uncertainty is likely to prevent their being put to the test in actual conflict. Anyway, the vessels carrying the plates will be practically obsolete before they can be re-armored. Better save the new plates for new vessels. Great warships nowadays are made for the purpose of preventing naval battles, which is a good thing, no doubt.

The frequency of boiler explosions, the cause of which can be traced to incompetency, pure and simple, naturally leads to the inquiry as to whether their owners are willing to take the risk of putting them in charge of men ignorant of their real duties for the sake of saving a few dollars in the way of wages. In many instances it looks that way. Men are gifted by nature with the love of taking chances, and there are men who would look with horror upon betting on horse races, or in Wall street, but who will cheerfully gamble on a boiler explosion, the stake being a few dollars in the way of wages between Competency and Incompetency on one side, and the killing of a few people and the destruction of more or less property on the other. Hence it is that so many boiler owners will not pay for inspection, or a good engineer, and will spend their money in seeing that license laws are not passed.

QUESTIONS AND ANSWERS.

Questions of general interest relating to subjects discussed in our columns will receive attention in this department. The writer's name and address should always accompany the question. Neither correct initials nor location will be published when there is a request to that effect. If questions are enclosed with a business communication, they should be written on a separate sheet.

(428) H. G. C., Memphis, Tenn., writes: Kindly give addresses of firms that make soap presses, dies, and cutters. *A.*—Write to press manufacturers; the addresses of these are given in our advertising columns.

(429) F. H. J., Angelica, N. Y., writes: In reply to Question 398 will say, that the White Machine Co., Waterbury, Conn., build match making machinery.

(430) J. B., Akron, O, writes: Kindly inform me from what source I can get a full description and explanation of the construction and working of the gasoline engine. *A.*—You will probably find the information you seek in the book entitled "The Gas Engine," by D Clerk, and published by John Wiley & Sons, New York.

(431) C. J. R., Chicopee, Mass., writes: Kindly inform me if "Machine Shop Practice," by J. Rose, is as good a book as any other treating on similar subjects, or are there works of a more recent date published? *A.*—We do not know of any other work that covers the same ground as the book above referred to, and neither have we seen one of a later date. 2. Please give title of a good work treating on wood turning? *A.*—"Turning for Amateurs," by J. Lukin, may suit you.

(432) C. J., Bridgeport, Conn., writes: There is a small book published that asks questions and answers them. Please inform me where I can find it, and give price. *A.*—There are a number of such books published. If you will state to what subjects the questions refer, we may be able to give the desired information. 2. Please inform me where I can buy drawings of machinery. *A.*—Write to publishers of scientific works, the addresses of some of these are given in our advertising columns.

(433) E. T., Philadelphia, Pa., writes: In speaking of a certain size of steam, gas or water pipes, does the outside diameter remain the same whether they are made of cast or wrought iron or copper? *A.*—No. In regard to your second question, we cannot work out the given formulas, because you do not state what quantities the letters signify. And in regard to your third question, we cannot recommend one technical journal in preference to others. Many news dealers keep the journals to which you refer on hand, and from these you can make your own selection.

(434) A. H., Chicago, Ill., asks: Do you know of any pipe tongs that will not injure the pipes when applied to the same when screwing the pipes together? *A.*—There are pipe tongs on the market for which it is claimed that by their use no injury to the pipes will result. We should advise you to write to manufacturers of this line of tools and machinery; they have made this subject a special study, and will undoubtedly furnish you with the best kind of tongs made. The addresses of some of these manufacturers you will find in our advertising columns.

(435) W. J., Florence, Mass., writes: In the AMERICAN MACHINIST of May 17th, current volume, you have an article about voting machinery. I should be pleased if you can inform me when these voting machines were patented, so as to enable me te obtain a copy of the patent specifications. *A.*—We do not know the date of the patent. It is possible that a file of the *Official Gazette*, of the U. S. Patent Office, is kept in your public library, which will enable you to make a search for it without any expense. If not, a patent attorney can procure a copy of the patent for you.

(436) W. C. B., ——, Illinois, writes: In your issue of May 3d, current volume, Question 215, E. G. S., asks: Is there a rotary engine made that works steam expansively? To which you answer yes. Kindly help me to find the builder of this engine, or from whom can I obtain illustrations of it? *A.*—Rotary engines are built at the Stone Bros. Iron Works, Homer, N. Y.; write to this firm and you will undoubtedly get the information you seek. 2. Where can I procure the two books mentioned in the same answer? *A.*—They are published by Macmillan & Co., 66 Fifth avenue, New York. You can also get them from any dealer in scientific works.

(437) E. M, Joliet, Ill., writes: Please inform me how great a force will be necessary to move the carriage on a steel jib crane by direct pull, the load being 3,000 pounds, the diameter of each of the four wheels is 6½ inches, and the journals are 1¼ inches in diameter. *A.*—If the steel jib is in good condition and exactly horizontal, and the journals also in a good condition and well lubricated, it will take a direct pull of about 9 pounds per ton of 2,000 pounds, making the total pull equal to about 13½ pounds for moving the carriage at a uniform rate of motion. To start the carriage from rest up to a uniform motion will require a greater force, which will depend on the acceleration.

(438) R. L. N., Richmond, Va, writes: I have a passenger engine of the old type built by McQueen. The extension frame is about 1½x6 inches deep, and where it laps between the cylinder and pedestal, a new set of bolts lasts about four weeks only. The bolts are properly fitted to straight reamed holes. They always break on the same side of the engine, and a careful examination shows that everything is tight. What is the cause of this breaking of bolts? *A.*—The breaking bolts on the same side of engine indicates that the stress on one side is greater than on the other. You will probably find that this is due to a faulty alignment, or due to a difference in the form of joints.

(439) C. W. S., ——, writes: Please inform me if a worm can be cut from an 8 pitch worm-wheel, on a lathe having a lead-screw 4 threads per inch, and what gears would be necessary? *A.*—We assume that you mean that the worm-wheel is 8 diametral pitch, this is equivalent to .393 inch circular pitch, which should be the pitch of the worm. The pitch of the screw, *i. e*, the distance from center to center of threads is .25 inch, and the gears must therefore be in the proportion of .393 inch to .25 inch, or what is the same thing, 393 to 250 Dividing both these numbers by 2 5 we find that gears 157 and 100 are very nearly right, and by dividing these by any other common divisor other gears perhaps more convenient or more easily obtainable can be found. For instance, dividing by 2.5 again, or what is the same thing, dividing the original numbers by 5 we get 78 6 and 50, and gears 78 and 50 would probably be near enough for this purpose.

(440) J. W. B., Home Wood, Ill., asks: Is there a gasoline burner made for brazing one-inch tubing; if so, from whom can I obtain one? *A.*—You can obtain one by writing to dealers in machinists' supplies; the addresses of some of these are given in our advertising columns. 2. Can rubber be melted in any way so that in cooling it will harden and return to its original state? *A.*—No. 3. Please give me the title of some good book which treats on machinery, blacksmithing, painting, varnishing, etc. *A.*—We do not know that such a book is published; probably the nearest approach to it is Appleton's "Cyclopedia of Applied Mechanics." 4. I am about to buy an engine of about 6 horse power; would you advise me to get a gas or steam engine? *A.*—In selecting an engine we should be guided by the locality in which the engine is to run, and the kind of work for which it is to be used. You will have to make your own selection. 5. Are gas engines reliable? *A.*—Yes.

(441) J. W. W., Gouverneur, N. Y., writes: I want to build a steam launch that will carry four persons comfortably. Kindly inform me what size hull I shall need. *A.*—Length, 16 feet; breadth, 4 feet 6 inches; depth, 2 feet. 2. What type and size of engine will be required, and will a condenser be of any advantage on so small a boat? *A.*—We should use a simple, vertical engine; diameter of cylinder 2 inches, stroke 3 inches. We should not use a condenser. 3. What type of boiler will be suitable? *A.*—A plain, upright boiler; diameter of furnace 18 inches; height of furnace 18 inches; diameter outside of shell 23¼ inches; height of shell 31 inches; diameter of flue 6 inches. 4 What should be the size of the propeller? *A.*—12 inches diameter, 21 inches pitch. 5. I would like to build the engine myself, and would like the address of parties who build small launch engines, from whom I could buy the castings and forgings. *A.*—Shipman Engine Co., Cortlandt street, New York, are builders of this class of engines, and they may furnish you with the castings and forgings.

(442) O. S., Anacostia, D. C., writes: Please inform me how many cubic feet of air at a pressure of 2 pounds per square inch can be obtained from 1 cubic foot at a pressure of 60 pounds per square inch. The above pressures are assumed to be absolute. *A.*—30 cubic feet. 2. An air tight and empty vessel displacing 1 cubic foot of water is placed 15 feet below the surface of the water, and two others at 10 and 5 feet respectively below the surface; what weight will each require to keep it under the water at the depths named? *A.*—That depends on the weight of the vessels; they may be so heavy as to cause them to sink without any weight attached to them. Assuming that each is light enough to float, and all of equal size and weight, then the weights required to hold them under water at the depth named will be equal. To show how these weights can be computed, we will take the following example: How great a mass of solid cast iron can be supported in water by a hollow wrought-iron cylinder weighing 30 pounds, and displacing 1 cubic foot of water, both bodies being completely immersed? We shall here assume that the weight of cast-iron is 450 pounds per cubic foot, and water, 62.5 pounds per cubic foot. The buoyant effort on the cylinder which displaces 1 cubic foot is

$$1 \times 62.5 = 62.5 \text{ pounds,}$$

leaving a residue of 62 5 — 30 = 32 5 pounds upward force to buoy the cast iron, whose volume V is unknown. The direct buoyant effort of the water on the cast-iron is $V \times 62.5$ pounds, and the problem requires that this force + 32 5 pounds shall be equal to the weight of the cast-iron which the cylinder is to support. Hence we have

$$V \times 62.5 + 32.5 = V \times 450;$$

this reduces to

$$32.5 = 387.5\ V;$$

hence

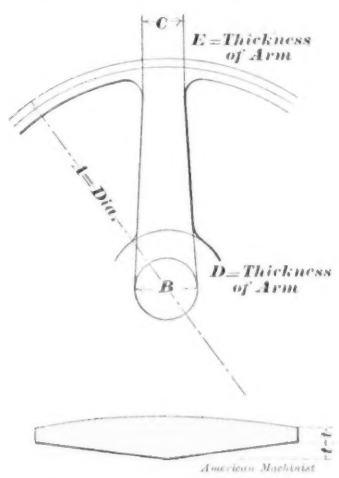
$$V = \frac{32.5}{387.5} = .083 \text{ cubic foot,}$$

and the required weight of the cast-iron will be

$$.083 \times 450 = 37.35 \text{ pounds.}$$

3. How long a time will it take for the air vessel to rise from a depth of 20 feet? *A.*—That depends on the weight and form of the vessel.

(443) G. L. S., Richmond, Ind., writes: Kindly inform me if there is a rule for making pulleys. I have been making arms and hub to weigh one third of the weight of rim. If this rule is correct, does it hold good for any size of pulley? I have seen a 102-inch pulley, 15 inch face, 8 1/16 inches bore, with 8 arms, weigh 1,692 pounds. The arms and hub weighed a little over one-third the weight of rim. The arms were 4⅜ inches wide and 1¼ inches thick at the hub, and 3½ inches wide and 1 inch thick at the rim. Hub, 13 inches diameter; rim, 1 3/16 inch thick. Are these arms too light, and



what horse-power will this pulley safely transmit at 60 revolutions per minute? *A.*—For ordinary practice, and for shops in which a multitude of pulley patterns is not permissible, the following empirical formulas will give satisfactory results. Let A = diameter of pulley; B = width of arm at the center of the pulley; C = width of arms at the circumference of pulley; D = thickness of arms at the center, and E = thickness of arms at the circumference of pulley. All dimensions in inches. Then

$$B = A \times .0625 + .5 \quad (1)$$
$$C = A \times .04 + .3125 \quad (2)$$
$$D = A \times .025 + .2 \quad (3)$$
$$E = A \times .016 + .125 \quad (4)$$

Change the decimal results to the nearest sixteenths. The dimensions as found by the above formulas are for elliptical arms. For closer calculations, in which the pull of the belt is taken into account, the following formulas may be used. For single belts:

$$B = .61 \sqrt[3]{\frac{\text{Breadth of belt} \times \text{dia. of pulley}}{\text{Number of arms.}}} \quad (5)$$

For double belts:

$$B = .77 \sqrt[3]{\frac{\text{Breadth of belt} \times \text{dia. of pulley}}{\text{Number of arms.}}} \quad (6)$$

All dimensions in inches. In these formulas 100 pounds is taken as the maximum stress for single belts per inch of width, and 200 pounds for double belts, and 2,000 pounds for the safe stress in cast iron. For the other dimensions of the arms we have:

$$C = \tfrac{2}{3} B \quad (7)$$
$$D = .4\ B \quad (8)$$
$$E = \tfrac{1}{3} D \quad (9)$$

The crown of the rim may be described with a radius equal to 3 to 5 times the width of the rim. The rim should be a little wider than the belt it is intended to carry. Let w = width of belt, and W = width of rim. Then

$$W = \tfrac{9}{8} (w + 0\ 4). \quad (10)$$

The thickness t of the edge of the rim may be

$$t = .7\ w + .005\ A. \quad (11)$$

The diameter of the hub is about twice the diameter of the shaft, and the length of the hub about twice the diameter of the shaft + the thickness D. Referring to the 102 inch pulley mentioned in your question, we have, according to formulas 1, 2, 3 and 4, the following dimensions for the arms:

B = 6.87 inches.
C = 4 39 "
D = 2.75 "
E = 1.95 "

According to formulas 6, 7, 8 and 9, assuming the belt to be 14 inches wide, we have:

B = 4 33 inches.
C = 2 88 "
D = 1.73 "
E = 1 15 "

There is quite a difference in the results obtained from these two sets of formulas, but this should not be surprising. The dimensions of arms obtained from the first set are suitable for belts wider than 14 inches, and results obtained from the last set are for this particular size of belt only. The arms of the dimensions given in your question are strong enough for the given width of rim. In regard to the horse power, a belt 14 inches wide running at a speed as given by you will transmit 44 5 horse-power, provided both pulleys over which the belt runs are of equal diameter.

BUSINESS SPECIALS

Transient Advertisements 50 cents a line for each insertion under this head. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue.

Gears, Lex'n, Poila., Cleve'd. See page 12.

Forming Lathes, Mer. Mach. Tool Co., Meriden, Ct.

Milling Machs. Kempsmith Co., Milwaukee, Wis.

Turret Drills, 6 spindles. A. D. Quint, Hartford, Ct.

"National" Lathe Chucks. Best made, page 15.

Pattern and Brand Letters. A variety of sizes and styles. Heber Wells, 157 William St., N. Y.

Selden Packing for stuffing box, with or without rubber core. Randolph Brandt, 38 Cortlandt St., N.Y.

American Packing Rings are correctly proportioned and accurately made; new circular about rings and pistons, 10c. J.H.Dunbar, Youngstown, O.

Guild & Garrison, Brooklyn, N. Y., manufacture steam pumps, vacuum pumps, vacuum apparatus, air pumps, acid blowers, filter press pumps, etc.

Improved Duplex and Special Gear Cutters in stock and to order; Gear and Milling Cutters of all descriptions. R. M. Clough, Tolland, Conn.

"Pumping Machinery." New book, 450 pp. 8vo, 270 Eng. Prospectus free. W. M. Barr, 3223 Powelton avenue, Philadelphia, Pa.

Model Locomotives. Complete sets castings N. Y. Central Standard up to date. Rough or finished. G. H. Olney, 163 Herkimer St., B'klyn., N. Y.

New Jersey Art Metal Co., Passaic, N. J., finest thin and ornamental castings in brass, bronze, aluminum, etc.; machinery name plates in brass and aluminum.

Grinders' Supplies—Emery, emery wheels, grinding machines, knife powders and sharpeners, paste and liquid polish, whetstones, etc., etc.; quick process and large stock. Customers annoyed by the delays due to long processes and small stock can get goods in a hurry by buying of The Tanite Co., N.Y. City, Cincinnati, O., and Stroudsburg, Pa.

"Binders" for the AMERICAN MACHINIST. Two styles, the "Common Sense," as heretofore sold by us and mailed to any address at $1.00 each, and the "New Handy," mailed at 50c. each. The former has stiff board covers, while the latter has flexible covers with full page opening flat. Either will hold the entire 52 issues of any volume. AMERICAN MACHINIST PUBLISHING CO., 203 Broadway, New York.

"Indicator Practice and Steam Engine Economy." By F. F. Hemenway. Contains plain directions for using the indicator and making all required calculations from the diagram, also the principles of economy in operating steam engines and current practice in testing engines and boilers. Price, $2 post paid. Published by John Wiley & Sons, 53 East Tenth street, New York.

"Modern Locomotive Construction." By J. G. A. Meyer. In this book the design and construction of all details of the locomotive and tender are considered from a practical standpoint. It contains illustrations of details made from working drawings, accompanied by plain directions for designing, and rules and tables for construction. Adapted to office and shop use. Price, $10. Published by John Wiley & Sons, 53 East Tenth street, New York.

A Note on Compressed Air.*

BY FRANK RICHARDS.

In offering the following paper for the consideration of the American Society of Mechanical Engineers, which embraces in its membership the ablest of investigators of mechanical efficiencies, it is not intended to challenge minute and exhaustive criticism, but rather to present the subject in such a way that it may attract as widely as possible the attention of the general mechanical public. I may be able to make it appear that the compressed air practice of the day is not sufficiently advanced to invite or to warrant the minute and careful analyses which belong, for instance, to the marine engine, to the pumping engine, or to the locomotive.

I think that compressed air has not received the attention which it deserves, and that where it has secured some attention it has not always had fair play. There are many men in these days, and many intelligent engineers among them, who will not

* Presented at the Montreal meeting of the American Society of Mechanical Engineers.

even consider the claims of compressed air as a means of power transmission because their minds have been so filled with the idea that its use entails enormous losses. That consideration settles it for them, and that is the libel from which compressed air suffers, so that it does not get a fair chance even to show what it can do. It is only another case of giving a dog a bad name; and in this case it is a very good dog with a very bad name. It is the worst kind of a case to set right. It is but common justice to tell the straight truth in the matter and to spread it as widely as possible.

The position of compressed air before the mechanical public, and especially the American mechanical public, has been a peculiar one all the way through. It has had no disinterested, all around friends to look after its interests, nor interested ones either. There have been no men, and still less any company of men, who have made the application of compressed air their business and have looked after it. Where is the general compressed air company performing for compressed air such functions as more than one company is performing for electricity, and why is there not such a company? Of the builders of air compressors not one of them has been, not one of them is to this day responsible for the economical application of compressed air *after the compression*, or apparently cares anything about it. Where compressed air has been used in this country, and where any thought has been given to economy in its use, the air compressor, it would seem, has been almost exclusively studied and talked about. In the progress of the steam engine it has sometimes seemed that the steam boiler has hardly received its proper share of attention, In the existing writings upon steam engine economy it is probably safe to say that the engine engrosses ten times as much of the matter as the boiler does. In the case of compressed air the boiler, or compressor, gets ten times as much study and discussion as the engine or motor which uses the air. There are such vagaries of injustice in civilized communities.

And this impression which has got abroad, of the waste of power in the use of compressed air has, curiously enough, been promoted and disseminated by the air compressor people more than by anyone else. We may say this with perfect safety, for it strikes so generally that it hits no one in particular. The compressed air literature accessible to the general public consists principally of air compressor catalogues. The argument of the average catalogue runs like this: "If you are going to use compressed air for any purpose look out for the enormous losses of power to be encountered and which you are sure to experience *if you don't buy our compressor*." And the result has been that many have "caught on" to the terrible tale of the waste of power, and have helped to spread it far and wide. The argument is of course not maliciously meant, but it has done more work, and somewhat different work, from what was intended.

Fig. 1 tells the whole story of compressed air. The piston F is fitted to the cylinder E so that we may assume it to move freely end without leakage. The piston being at A, as shown, and the cylinder being filled with air at a pressure of one atmosphere, and at normal temperature, a sufficient weight is placed upon the piston to force it down into the cylinder and compress the air contained in it to a pressure of, say, six atmospheres. The volume being inversely as the pressure the piston should go down to C. We find that it actually only goes down to B, and the reason is that while the air is being compressed the operation of compression also heats it, and the heat distends or expands the air, and its volume is consequently considerably greater than it should be upon the assumption that the volume is always inversely as the pressure. Supposing both the piston and the cylinder to be absolute non-conductors of heat, and that the air heated by the compression loses none of its heat of compression, then if the weight which forced the piston down be taken away the piston will be driven back to its original position at A, and the air contained in the cylinder will have resumed its normal pressure and temperature, and will have done as much work, or will have exerted as much force, by its return as was employed in the act of compression. If while the piston was at B, and with the weight upon it sufficient to balance the pressure of six atmospheres, the air by any means had been cooled to its original temperature the piston would have fallen to C, and the law that the volume varies inversely as the pressure would have held good, as then the initial and final temperatures would have been the same. The air being thus cooled to its original temperature, and the piston being at C, upon removing the weight from the piston it would return only to D instead of to A. When the piston arrived at D the pressure of the air in the cylinder would have fallen to the original pressure of one atmosphere, and the piston at D would be balanced between the equal pressures above and below it. As the air is heated during the operation of compression, so is it equally cooled during its expansion, and when the piston reaches D the air in the cylinder is then at atmospheric pressure, because it is then much colder than it was at the beginning; and it is solely because of this loss of heat that the pressure falls so early, and that the piston does not return to A where it started from. If while the piston is at D the air can by any means recover all the heat which it has lost the piston will return to A as before. The distance D A compared with C A represents the total possible theoretical loss of power in the compression and the re expansion of air.

Fig. 2.

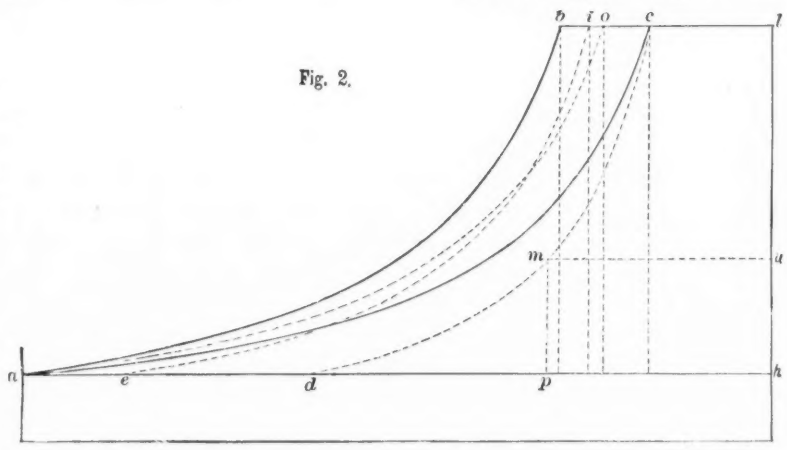
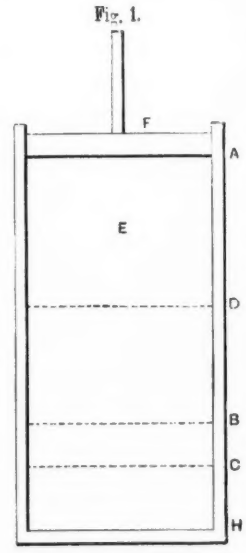


Fig. 1.



We may now consider the practical aspect of the case. And, beginning at the very beginning, with the practical compression of the air, we cannot but notice how readily the air lends itself to economy in its use. By the way in which it is possible to connect the air-compressing cylinder with the steam engine in the best air compressors at the present day, no power is lost in operating the piston of the compressing cylinder, or, stated more accurately, the entire friction of the air-compressing apparatus is so compensated for by the saving of friction in the engine that it is not only reduced to zero but it becomes a negative quantity of considerable magnitude. This may be proved by incontrovertible evidence. The air compressor, it will be noted, comprises a complete steam engine, with all its component operating parts, steam piston, crosshead, connecting rod, crank pin, crank shaft, complete valve motion, etc., and in addition to these there is the air piston to operate, and it is natural enough to suppose that the operating of the air piston puts just so much additional friction upon the engine, with a call for so much more power to overcome it. But the arrangement of the air piston in a straight line and upon the same rod with the steam piston saves enough from the friction of the engine proper to more than compensate for the friction of the air piston, and the operating of the air piston costs practically "less than nothing." In a regular stationary engine which transmits its whole power through the crank shaft, and by its driving pulley, gears, or otherwise, wherever it may be wanted, the whole power exerted is felt in friction upon the crosshead slides, connecting-rod boxes, crank pin, main bearings, etc. In the air compressor most of the power of the steam engine is transmitted directly from the steam piston to the air piston without the intervention of the engine friction. Not only is the effective steam pressure so immediately transmitted, but the force due to the inertia of the reciprocating parts, especially the heavy crosshead which is usually employed, is sent directly to the air piston through its piston rod.

The losses due to the friction of the ordinary stationary steam engine usually amount to 10 or 12 per cent. of the indicated horsepower. In an Ingersoll-Sergeant air compressor exhibited at Chicago, with engines of the Corliss type, the mean friction as determined by Professor Jacobus was 5 per cent., so that crediting the saving of friction to the air cylinders, the friction cost for operating them was — 5 to — 7 per cent.

The diagram, Fig. 2, scale 40, is intended to show the practical possibilities in the use of compressed air at 75 pounds gauge, or six atmospheres. The line a b is the adiabatic compression line, or the line of compression, assuming that no heat is taken away from or lost by the air during the compression. The initial temperature of the air being 60 degrees, the final temperature would be about 415 degrees, and the final volume is .28 of the initial volume. The line a c is the isothermal compression line, which assumes that all the heat of compression is got rid of just when it is produced, or that the air throughout the compression remains constantly at its initial temperature. The final volume in this case is .1666 of the initial volume. Remembering that these lines, a b and a c, represent the compression of the same initial volume of air, it is evident that there is quite a difference in the power employed in the two cases, and herein lies the loss, or the possibility of loss, of power in the operation of compression. The mean effective pressure, or resistance, of the air for the stroke on the adiabatic line a b l is 35.36, while the mean effective pressure for the isothermal line a c l is but 27, or only 76 per cent. of the former. The comparison should, however, be made the other way. The adiabatic mean effective pressure is 130 per cent. of the isothermal mean effective pressure, and the 30 per cent. is, of course, the additional, or, as we might say, unnecessary power employed. Neither of these lines, a b or a c, is possible in practice. Air cannot be compressed without losing some of its heat during compression, so that the actual compression line must always fall within the line a b. On the other hand, it is equally impossible to abstract all the heat from the air coincidently with the production of that heat, so that the actual compression line must always fall outside the line a c. The best air compressor practice of to-day is very near the line a o, or the mean of the adiabatic and the isothermal lines. The actual line is generally outside of this, and seldom inside of it. It would be impossible to produce a line exactly coincident with this in practice. If we produced a line giving the same mean effective pressure as a o, it would probably run above a o for the first half of the stroke, and perhaps a little below it at the last. If the compression were "compound," or done in two cylinders there would, of course, be a break in the continuity of the curve. The mean effective pressure for the line a o l is about 31.5, or still nearly 17 per cent. in excess of the mean effective pressure for the line a c l As this is for what must be considered exceptionally good practice, the loss of power for the average practice in air compression may be put at 20 per cent. Lest some impatient ones should drop the subject here, or lest some rival of compressed air should pick up this and run away with it, we might insert a reminder here that all this loss is not necessarily final. It is proper to compare the actual compression line a o l with the ideal isothermal line a c l, because the volume c l is the volume available when the air is put to use. Though at the completion of the compression stroke there is always some of the heat of compression remaining in the air, and its volume is greater than c l, that heat is always lost in the transmission or the storage of the air, and the available volume is never practically above c l.

After the air has been compressed, and before it is put to use, it is usually transmitted through pipes for some distance, and the friction of the air in its passage through the pipe naturally causes some loss of pressure. Here again the air compressor people have —unwittingly, we will say—done more harm than good as regards the interests of compressed air. Formidable tables are in all the air compressor catalogues, showing the loss of pressure due to the friction of air in pipes, and timid investors, seeing them, have another fright. The tables are not dangerous, and are not published primarily for the purpose of frightening people away. They are only intended to suggest the size of pipe most suitable for any given case of transmission. If they tell us truly of the loss of pressure, they still fail to tell us that the loss of pressure is not necessarily, or to the same extent, a loss of power. The actual truth is that there is very little loss of power through the transmission of compressed air through proper pipes to a reasonable distance, and the reasonable distance is not a short one. With pipes of proper size and in good condition, air may be transmitted, say, ten miles, with a loss of pressure of less than 1 pound per mile. If the air were at 80 pounds gauge, or 95 pounds absolute, upon entering the pipe, and 70 pounds gauge, or 85 pounds absolute, at the other end, there would be a loss of a little more than 10 per cent. in absolute pressure, but at the same time there would be an increase of volume of 11 per cent. to compensate for the loss of pressure, and the loss of available power would be less than 3 per cent. This illustration is only offered as a simple and convenient one, and not as a sample of the best practice. With higher pressures still more favorable results could be shown.

Having compressed the air and conveyed it to the point where we wish to use it, we may turn again to Fig. 2 and see what we will be able to do with it. The air may be used in various ways with widely different economic results. Having the volume c l, and using it in a cylinder of suitable capacity, cutting off so as to expand down to one atmosphere before release, the adiabatic line, or the lowest expansion line that the air could make, would be the line c d, and the total loss in the use of the air, as compared with the power cost of compressing it, would be the difference between the areas a o l h, and l c d h, the latter being 66 per cent. of the former The temperature of the air at c where the expansion begins, being assumed to be 60 degrees, the cooling of the air which always accompanies its expansion will bring the temperature far down the scale when d is reached, d being, of course, the end of the cylinder wherein the expansion takes place. The theoretical

temperature of the air at the end of the stroke would be about — 150 degrees. The actual temperature is never found as low as the theoretical temperature, because the air receives heat from the cylinder and the walls of the passages with which it comes in contact, but it is usually still cold enough to cause serious inconvenience in practice, and unless some remedy be devised, this cooling of the air is fatal to its employment, entirely regardless of the economy of the case. The air almost invariably contains moisture, the amount varying with the surrounding meteorological conditions, and as the air becomes attenuated and so intensely cold the water in the air is rapidly deposited and frozen in the passages, and soon chokes them up and stops the operation of the engine. So it is useless to try to use compressed air generally, and with general satisfaction, without some means of heating the air immediately before it is set to do its work. For some purposes the air may be and is constantly used without reheating. Hoisting, when done directly, and not by means of a hoisting engine, is, from its intermittent character, not likely to exhibit the freezing phenomenon. Besides, the intermittent action of the hoist, giving time for the parts mostly to recover their temperature between the successive hoists, the air in direct hoists is not accompanied with the expansion of the air in the cylinder before its discharge, which expansion, where it exists, is productive of such intense cold. There is occasionally some trouble about operating rock drills on account of their freezing up, but not very often. They are more or less intermittent in their action; they do not generally use the air with much expansion in the cylinder, and the exhaust is sharp and heavy. Many steam pumps are now run by compressed air without its being reheated, never with proper economy, but without their passages freezing up. They generally use low pressures of air, say 20 or 25 pounds, in a great many cases, and they carry a nearly uniform pressure for the whole stroke, so that if there is any trouble about their freezing up it is in the exhaust passage after the air has done its work, and jets of water or some other means of supplying a little necessary heat are sufficient to keep them going. The reheating of the air, where practiced, not only brings us out of our trouble about the freezing up of the parts, but it increases the volume of the air and its consequent available power at a very slight expense for the heating. If the volume of air $c\ l$, being now at 60 degrees, be passed through a suitable heater and its temperature raised to 300 degrees, its volume will then be $i\ l$, instead of $c\ l$, or .2434 instead of .1666, an increase of volume of about 50 per cent. In practice, to insure a temperature of 300 degrees in the cylinder at the beginning of the expansion, it will be necessary to heat the air considerably above that temperature, say to 400 degrees, as the air loses its heat very rapidly. If now we use this air by filling the cylinder to i and then expanding down to e, supposing the temperature at i to be 300 degrees, the theoretical final temperature will be about zero. The actual temperature, it is pretty certain, will not be below the freezing point, and all our trouble about the freezing of the passages will have disappeared, and the power realized will have been much increased. The use of the reheater being so obviously a necessity, we naturally should find it, in various styles, occupying a prominent place in the catalogues of the air compressor people. Actually and unnaturally, we do not find such a heater in any catalogue, to my knowledge.

As to the cost of reheating the air, it is scarcely within the scope and purpose of this paper to offer any precise data. Such data are easily accessible to any who wish to investigate the subject. I may say, however, that a greater mechanical effect is realized from heat applied to the reheating of compressed air than from any other known application of it, which consideration should urge us to extend its most economical use. There are many purposes, as, for instance, mining and all subterranean operations, where compressed air already *must* be used, regardless of all considerations of economy. There are many others, as, for instance, general hoisting work, where it already *pays* to use compressed air. The extension of its use to the general purposes for which the steam engine, the gas engine, or the electric motor are used is distinctly waiting for the general introduction of cheap, efficient, and, above all, "handy" means of reheating the air.

It is quite practicable, by effective cooling of the air during its compression and by reheating it before its re expansion, to bring the expansion line, *i. e.*, to inclose an area not less than that inclosed by the compression line $a\ o$, and then the entire losses will be those attributable to the clearances and to friction. In practice 85 per cent. of the initial power has already been realized after transmitting the air to considerable distances.

It was remarked above that the air after compression and transmission might be employed with widely different economic results. As an instance of how not to do it, I might cite the case, of too frequent occurrence, where air is delivered to a mine for operating rock drills and other mining machinery, and then air is taken from the same line for operating a pump. This practice would be all right if the pump were adapted to the work to be done and to the pressure of air carried. The pump, however, is generally a common direct acting steam pump, which has been obtained without any reference to the economical use of air. As it has probably already been run by steam, or is designed to be run by steam, it calls for a low operating pressure; this being a necessity on account of the condensation of the steam when transmitted through long pipes. Say that the compressed air pipe carries 75 pounds pressure, while the pump only requires 25 pounds. It would be an advantage, in a case like this, to use a pressure reducer in the pipe at a considerable distance from the pump, so that the expansion to the lower pressure required might take place, and the air have an opportunity to recover its temperature and volume before going into the pump. This, however, is seldom attended to, and the required reduction of pressure is effected entirely by the throttle at the instant of admission. The available power, then, when the air is so employed, will be represented by the area $p\ m\ n\ h$ as compared with the area $a\ b\ l\ h$, or, at the best, $a\ o\ l\ h$, representing the power that was expended in compressing the air. Then, if we deduct the losses attributable to the useless filling of the large clearances of the common steam pump, and to the leakages which are an universal accompaniment of general loose practice, and consider also the freezing up of the pump, which is almost inevitable in such a case, it is little wonder that compressed air is held in little respect. Under circumstances far from the most unfavorable, I have found pumps realizing only 15 per cent. of the power expended at the compressor, and I have no doubt that there are many pumps being operated, or whose operation is attempted, where not more than 10 per cent. of the original power is realized; and even then, when the use of compressed air for operating such pumps is condemned, it is because the pumps freeze up and will not go, rather than on account of the enormous waste of power. From the fact that the duty of a mining pump is a nearly constant quantity, the pump, if properly proportioned and adapted to its work, should be an efficient missionary for compressed air rather than its most malignant traducer.

The word "loss," we have been using in connection with this subject, is a somewhat incorrect and misleading one. The use of compressed air is for the accomplishment of a desirable purpose, and it is not to be expected that such a purpose can be effected for nothing. The transmission of power is as much to be paid for as the generation of the power. Where water power is used the means of transmission may be the principal item of cost. Where the difference between the power expended and the power realized is not excessive, that difference is simply a fair price paid for a good service rendered, and there is no loss about it. Where losses do occur in the use of compressed air, they are like the losses which occur in business, and which cut short many a brilliant career. Power is lost simply because it is not saved, and the means of saving are not hard to find nor far to seek. The losses are not necessary nor unavoidable, nor without compensation. It is a failure to understand and appreciate this situation which impedes the progress of compressed air.

There is a view of this question of compressed air economy which makes it appear somewhat absurd. It is quite possible, as we have seen, to realize from our motor 80 or 85 per cent. of the power received at the air compressing cylinder. In comparison with this what kind of a model of economy is the steam engine which is in such universal use? The consumption of water for supplying steam engines ranges from, say, 12 pounds per horse-power per hour up to 30 pounds, and away above that, and the consumption of coal per horse power per hour from, say, 1½ pounds up to 8 or 10 pounds. One may stand in any city or large town in the country, and within a mile of him may be found an engine and boiler using over 400 per cent. of the coal per horse power per hour which is used in the best engines, yet nobody goes around whining about the enormous loss of power in the use of the steam engine, or tries to discourage anybody from using it, or even seriously tries to promote a better efficiency. It is probable that the air-compressing cylinders of the principal builders of compressors do not vary more than 10 per cent. in the economy of their compression. I would hesitate long—and then, of course, refuse—to say that the economy of the steam end of the same compressors showed no more difference than that.

The Critical Side of Mechanical Training.

As a supplement to, and confirmatory of the ideas advanced by President Eckley B. Coxe in his address at the Montreal meeting of the A. S. M. E., we republish below a portion of an editorial article from *Engineering* which is based upon recent remarks of an engineer and teacher of engineering; a recognized authority in all lands where mechanical engineering is practiced. The article in question is entitled as above and is in part as follows:

"Since I have ceased to teach I seem to have been spending my time in finding out how much better I could now do it than was possible when I was actually engaged in it." So spoke Prof. A. B. W. Kennedy in his inaugural address to the Mechanical Science Section of the British Association at the recent meeting, and his words constitute a grave warning against a recent development of engineering education. Here we have a distinguished engineer, who was a thorough engineer before he became a professor, who continued to practice as an engineer while he was a professor, and who, after giving up professorial work, rapidly attained such eminence that he was elected in the same year president of the Institute of Mechanical Engineers and president of the engineering section of the British Association, publicly confessing that his methods of teaching were imperfect for want of wider experience on his own part. What must have been the feelings of the numerous juvenile professors in his audience whose early engineering training was almost entirely at college, and who are debarred, by the terms of their agreements, from taking private practice now. They must have felt that all the charges so flippantly brought against them by the self styled practical men, were mere feather strokes compared with this crushing blow from one whom they look up to as an exemplar, and whose methods they all imitate. The sneers of ignorance—often impertinent and undeserved—they can afford to despise, but the self-reproach of a past master of the art cannot be so met.

The systematic teaching of engineering science has not, with some trifling exceptions, been a recognized part of collegiate instruction for more than about thirty years. At the commencement it was a difficult matter to find suitable men to fill the chairs, or rather, to prevail upon them to do so. Those who were competent felt that to attempt to teach engineering by aid of blackboard and piece of chalk was merely to court failure, and the ideas of the educational authorities did not go beyond those simple appliances. Not only had the art of teaching to be invented, but the fact that its prosecution needed money and appliances on a lavish scale had to be driven into the minds of those that controlled the purse-strings. Three classes of men were eliminated from those that had the necessary knowledge, namely, those that disliked teaching, those that did not see how to impart their knowledge in a class room, and those that objected to the preliminary labor of extorting the necessary apparatus from the authorities. Of those that undertook the work, none has left so great an impression upon it as Professor Kennedy, for it was he that bridged the gulf between practical and theoretical work by the institution of the engineering laboratory. He came to the work from the shop and the drawing-office, filled with a sense of the daily needs of the engineer, and he invented methods by which a provision for those needs may be made within the walls of a college. Yet, five years after severing his connection with teaching, he exclaims, "How much better I could do it now!"

The engineering professor of to day enters upon his duties under very different circumstances. He has a recognized calling, with well known methods and an accepted curriculum. The requirements of his department for an expensive outfit are well-known, and he has neither to invent new systems of teaching nor to convince the college board that his necessities go beyond a supply of chalks. Usually he is a man with a brilliant record. After some three or four years in an engineering shop, or office, he has gone to college, and has secured high honors. But when his course expired, he found his success acted as a bar to his progress. He had made a record, and must live up to it. His original idea had been to return to the shop or the office, and to use his theoretical knowledge to enable him to rise from among his less cultured comrades; but to start as an improver, or as junior draftsman at £1 per week, seemed very distasteful. After securing the praises of his professors, and the envy of his comrades, as the leading man of the year, the drudgery and commonplace surroundings of an engineer's shop, under the supervision of managers and head draftsmen innocent of mathematics, and possibly of grammar, appeared absolutely repulsive. A demonstratorship, or an assistant professorship, falling vacant during the period of his indecision, turned the current of his life. It offered a fair salary, short hours, and abundant holidays, and he could not resist the temptation to accept the post, at least temporarily. It was an easy step to the occupation of a chair, and thus his career was finally settled.

The modern professor is a capital man within the limits of his training, and has done very valuable work. The laboratory affords him opportunities that are closed to most engineers, and he uses them liberally. The instruction he furnishes to his students in the science of engineering is most valuable, but it might be far more so, if the teacher knew by daily experience the kind of problems they would have to solve in future life. Professor Kennedy stated to his audience that he could now teach better than he did five years ago, the change being due to the wider experience of his life since he had devoted all his time to professional work, and possibly to an extended acquaintance with the ways of technically educated assistant engineers. The point he would now give more attention to is the critical side of mechanical training, an aspect which, he says, is not always sufficiently kept clearly in view. This power of criticism

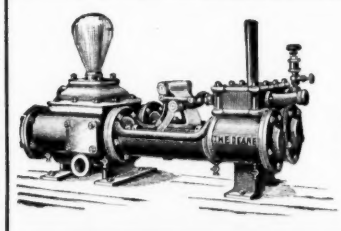
depends upon an ability to take in all the facts of a question, and to assign to each of them its proper value. Generally in engineering many of the factors have to be guessed at, or, at any rate, judged of by standards which do not admit of exact definition. These standards are the result of hundreds of half-forgotten impressions that leave in the brain a resultant effect which we call experience. By an unconscious effort the skilled engineer measures each feature of the matter under consideration by the nearest scale that he can find in his mind, and thus he is able to establish a sense of proportion which guides him to his conclusions. The phrase "mechanical extinct" is often used to denote this power of judgment, because its possessors are not unfrequently quite unable to define the mental processes by which they work, their methods being apparently akin to those by which constructive animals, such as bees and birds, reach their ends. It is, however, strictly ratiocinative, and can, therefore, be cultivated, like the logical or mathematical habit of mind. But it must be confessed that college methods are, in themselves, antagonistic to it, and hence the great necessity that unceasing vigilance should be exercised to find antidotes to their influence.

Professor Kennedy points out that in physical investigations every condition must be absolutely understood. "In such investigations it sometimes almost becomes immoral to think of one condition as less important than another. Every disturbing condition must be either eliminated or completely allowed for." The temptation to the engineering student to adopt the methods of the physicist is almost overwhelming. The learner must, of necessity, proceed step by step, and he must concentrate his whole attention on each step, if he is to study it successfully. This, however, is an attitude of mind that destroys all sense of proportion, and makes the object at the end of one's nose appear the largest thing in the world. Nothing but the most determined and continuous efforts on the part of the professor will prevent his students contracting mental myopia. He needs to keep in mind the practice of the painter, who is continually stepping back to survey his work from a distance. It may be that he is drawing a minute flower at the edge of his canvas with microscopic fidelity, but from time to time he takes a general survey of its effect on the entire composition. It should be the set aim of the technical teacher to induce in his students such a mental habit that at every pause they should shift their standpoint, and for a moment assume a position which allows the features of the problem before them to appear in true perspective. It is uphill work counteracting an influence that never ceases, and which must not be removed, and the more so when the teacher has not been taught, by the severe experience of the world, the absolute necessity of the duty. The modern professor has been subject to exactly the same forces as his pupils, and is so still. To teach the science of engineering by the methods of the physicist is both pleasant and easy, and perfectly meets the demands of the examination room. It needs a strong man to be always telling his pupils that he can only teach them one sixth of their trade, and that they will have to learn the remaining five sixths in the ruder school of experience. It is unsatisfactory to proclaim that although the matter under consideration can—and must be as an intellectual exercise—be investigated to the fifth decimal place, yet it is so bound up with other obscure factors, that the decimals are valueless—and the units also. It is discouraging to the pupil who is poring over the microscope—figuratively speaking—to be ever and anon rudely dragged back to a distance of several feet, and bid look how small is the thing he is devoting his attention to. If the little things could be dismissed as of no importance the matter would be simple, but the "next to nothing" of one problem becomes the governing feature of another, and hence it must be studied as completely as possible. The engineering student can never settle down into a comfortable mental attitude. He must be ever on the move, and it is the business of his professor to so arrange his curriculum that this is obligatory. In other words, his teacher must insure that he shall cultivate the critical side of his intellect.

The college cannot turn out capable critics any more than capable engineers, firstly, because the critical faculty cannot be acquired, to any great extent, in three years; and, further, because the knowledge imparted is restricted to that of the professor, who usually is wanting in acquaintance with many conditions that can only be learned by experience in the world. Evidence of this deficiency is afforded by a humorous letter from Mr. J. S. Raworth to our contemporary, *Lightning*, in which he proposes a night school for the better education of consulting electrical engineers, who are mostly professors. His plan is that there shall be regular gatherings in an evening, during which constructing engineers shall lecture on the practical side of electrical engineering, giving special prominence to those points upon which depends cheapness of construction, and showing how greatly indulgence in fads adds to cost, and at the same time decreases the possible profits of contractors. Although the letter was evidently a joke, yet it doubtless was the expression of a painful experience in having to work to instructions framed by men who are not versed in the details of manufacture. The sense of proportion, upon which Professor Kennedy dwelt, cannot govern a designer who is ignorant of the whole series of operations by which his plans are to be carried out. An improvement, desirable in itself, may necessitate a score of other unforeseen alterations, all of which will be expensive, and possibly some of them actually detrimental. As Mr. Raworth pointed out, he would be a bold man who thought he had nothing to learn from such heads of firms as Mr. Alexander Siemens and Mr. Crompton, while nothing but the widest knowledge should justify a demand for alterations in plans which are the outcome of their matured experience. In them the critical faculty has been trained by hundreds of full-sized experiments, the concrete results of which have shown themselves, sometimes painfully, in the cost sheets.

It is impossible for an engineer to consider that the critical side of his mechanical training is complete without a knowledge of costs, and this is matter that cannot be learned within the walls of a college. His clients, or his employers, expect him to save them money, and it is for that purpose that they consult him. He has to steer them between the dangers of cheapness, followed by excessive working expenses, and those of outlay so lavish that no future economy can recoup them. He is the best engineer that gets the most results for a given expenditure of money. His designs may be faulty—they may be flatly unscientific in some respects—but if they are really economical, they are the evidence of a trained critical faculty.

Young men often wonder at the confidence placed in elderly engineers, whose knowledge and ability they hold in the meanest esteem. They see their opinions accepted without demur, while their own utterances are treated with levity. In comparing their own knowledge, subject by subject, with that of these seniors, they find the balance always on their own side, and they wonder how it is that the public place such a low estimate on their capabilities. But the public know that the critical faculty is a plant of slow growth, and that without it knowledge is of very little value. It is a fair presumption that it is not far developed in a young man, and it is, therefore, a difficult matter for him to convince the world of the contrary. We would strongly advise our younger readers to ponder well Professor Kennedy's words, and to apply themselves to the cultivation of a broad attitude of mind. It is the best means for the detection of mistakes, for the most careful worker may make an occasional slip. We once heard of a young engineer who gravely presented his chief with an estimate for a small electric wiring installation, containing an item of three tons of putty for making good the casing. His critical faculty was evidently non existent. The original mistake in arithmetic was, doubtless, mere inadvertence, but the inability to instantly detect it showed that his technical education had left in their native fallowness some of the most important parts of his intellect. We wonder whether Professor Kennedy has had any such engineers assisting him, and giving him an object lesson in collegiate methods.



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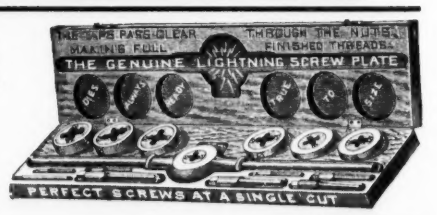

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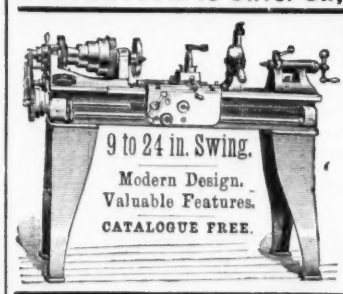

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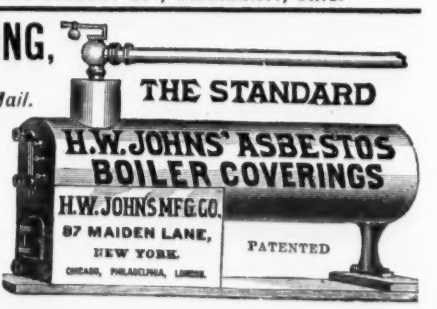

MANUFACTURES.

A stock company may be organized to locate a $20,000 knitting mill at San Angelo, Tex. Leon Halfin is interested.

Maris & Beekley, of Philadelphia, are furnishing one of their 10-ton cranes to the Tokio Electric Light Co., Tokio, Japan.

The Burden Iron Company, of Troy, N. Y., will resume operations in its puddling department, putting 65 furnaces to work.

The Grand Crossing (Ill.) Tack Co. will increase capacity by adding machines bought at the sale of the Florence (Mass.) tack works.

The Berlin Iron Bridge Co., of East Berlin, Conn., are building a large addition to the machine shops of Henry R. Worthington, at Brooklyn, N. Y.

The Automatic Bank Punch Co.'s office is now located at the manufactory, 83 Washington street, Brooklyn, N. Y. The president is James Brady, of the Brady Mfg Co.

The Berlin Iron Bridge Co., of East Berlin, Conn., have received the contract for an annealing room building for The Naugatuck Malleable Iron Co., at Naugatuck, Conn. The building is 94 feet wide and 175 feet long, with brick walls and iron roof trusses covered with corrugated iron.

The Morgan Engineering Co. Alliance, Ohio, have a contract to construct for the Metropolitan West Side Elevated Railway Co., of Chicago, for serving the power station, one of their four-motor electric traveling cranes of 35 tons capacity, this crane being fitted with their patented auxiliary hoist operated by an independent motor.

The Babcock Printing Press Company, with works at New London, Conn., and office at New York, issue a circular that is, as it naturally would be, a model of typographical effect, but in addition gives a good deal of knowledge in "the art preservation." If anyone is interested in the art of printing, it would be well if they asked for a copy.

W. H. Brown Sons, of Pittsburgh, Pa., have recently ordered of The Egan Company, Cincinnati, Ohio, one of their latest band sawing machines for the sawing and shaping of ship and barge timbers to such shapes as may be desired. The Messrs. Brown Sons have extensive boat yards at Brown's Station on the Monongahela River, above Pittsburgh some thirteen miles, where they build and repair their own coal barges.

We have frequently alluded to the part the band re-saw is playing in the modern practice of getting out lumber at a saving of raw material and time. We are informed that with a No. 7 machine of this type, made by J. A. Fay & Co., of Cincinnati, for the Michigan Lumber Co., of Holly, Mich., with a 5 inch saw, more than 50,000 feet of lumber was cut in one day of ten hours recently, the work being perfect, as such work cuts.

Jones & Lamson Machine Co., Springfield, Vt., write us under date of September 8th: "Orders which we have received for the flat turret lathe within the last eight days equal in number and amount the orders received between the dates of June 1st and September 1st. Since these orders have been taken without any change in our methods for securing orders (advertising and traveling), we think it is a fair indication of a general revival. We find that labor-saving machinery is preferred to wage-cutting, which seldom cuts the cost in the machine shop, and believe that the new conditions of the market will call more largely for labor-saving machinery as soon as there is any work to be done."

The Tradesman, Chattanooga, Tenn., in its report on the industrial condition of the South for the week ending September 10th, says: The record of the week is one of steady progress. The iron industry is getting more active each day as furnaces go into blast and outputs increase. Stocks of pig-iron are not increasing, but prices continue to be very low. The only cotton tie mill in the United States is now in active operation in Georgia, and seems to be able to meet any competition. The building industry is growing active in all the Southern cities, and many edifices requiring for their completion large investments of capital are under way, or in preparation for contracts. The condition of the crops continues to be satisfactory. Reports as to the injury to cotton from boll worms prove to have been much exaggerated. *The Tradesman* reports 33 new industries as established or incorporated during the week, prominent among them being an oil mill at Temple, Texas, with $100,000 capital; the Automatic Fire Extinguisher Co., of New Orleans, La., capital $10,000, and the Georgia Pebble Phosphate Co., of Atlanta, Ga., with $30,000 capital. An Immigration Aid Association, with $500,000 capital, has been chartered in Atlanta, Ga.; the Eureka Manufacturing Company, with $70,000 capital, will engage in woodworking in Houston, Texas; the Garrigus Boiler Cleaner Company, capital $20,000, has been chartered in Louisville, Ky.; the Currence Milling Company, capital $15,000, in Parsons, W. Va., and the Tomlin Harris Machine Company, with $10,000 capital, in Cordele, Ga.

Machinists' Supplies and Iron.

NEW YORK, September 15, 1894.

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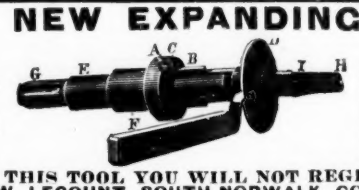

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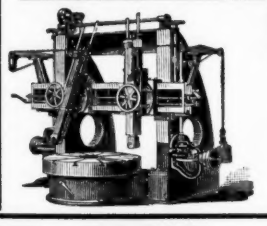

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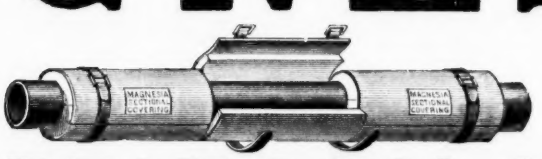

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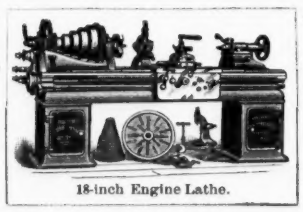
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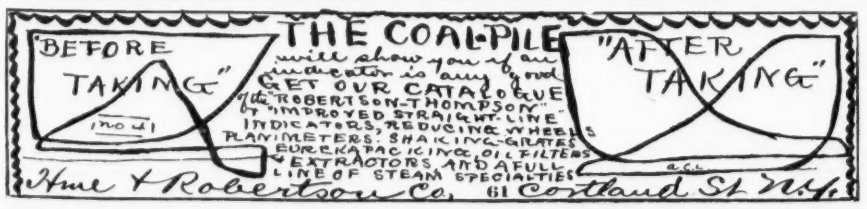

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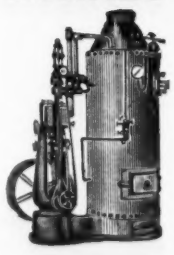

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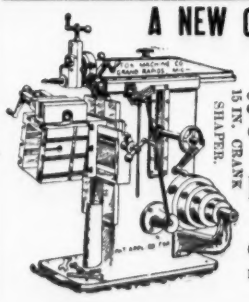

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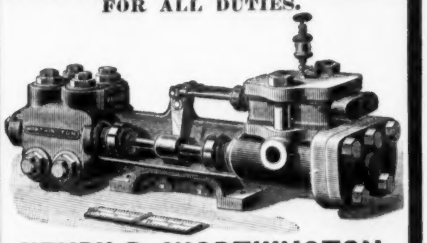

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Sit. wanted by a steady machinist, 32 years old, 15 years' exp. Machinist, AMERICAN MACHINIST.

Mech. draftsman, young man, wants pos. Good photographer. Salary low. J. W. F., AM. MACH.

Agents in every shop to sell my "Vernier" calipers. Big commission. E. G. Smith, Columbia, Pa.

Draftsman, grad., 6 years' exp. in eng. and boiler work, wants position. Box 7. AM. MACHINIST.

Mech. draftsman, an American, 28 yrs old, wants a permanent position; best refs. Box 13, AM. MACH.

Wanted—Mech'l, elec. engrs., draftsmen, machinists; tech. work. No conflict with pres. employment; no canvassing. Edwin Guthrie, Wash'n, D.C.

Mech. eng., with 12 years' practical experience in designing of steam and general mach'y, member of A. S. M. E., is open for pos. Box 9, AM. MACH.

Young man, 21, wants position; 3½ years experience at machine pattern making; can work well from drawings. Box 12, AMERICAN MACHINIST.

Wanted—A situation by a draftsman. Experienced on automatic machinery and special tools—American. Address Box 15. AMERICAN MACHINIST.

A first-class machinist and foreman of shop wants similar position. Can change in not less than 30 days' notice. Box 16, AMERICAN MACHINIST.

Situation wanted by practical machinist and toolmaker as superintendent or foreman. Address, Box 18, AMERICAN MACHINIST.

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Wanted—Foundryman to take charge of modern foundry; one who is thoroughly competent and can invest some capital; investment will be secured. Address, P. H. H., AMERICAN MACHINIST.

Open for engagement, reliable party, expert in steam, hydraulic and other mach'y; has been assistant supt. and chief draftsman before. Moderate terms. Address, "All Around," AM. MACHINIST.

Experienced and reliable person wishes to identify himself with some enterprising manufacturer or dealer in capacity of assistant superintendent, salesman, or to superintend the installation of machinery, steam plants, etc.; correspondence solicited. Address, Hustler, care AM. MACH.

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Advertisements will be inserted under this head at 35 cents per line, each insertion. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

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Wanted—To buy the patent of a small article to be manufactured. Address, B., AM. MACHINIST.

Draftsmen's new conveniences for rapid work. Send for blue print. D. J. Kelsey, New Haven, Ct.

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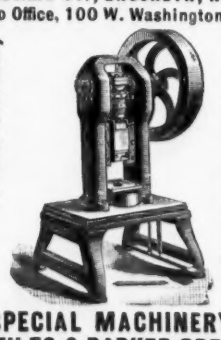

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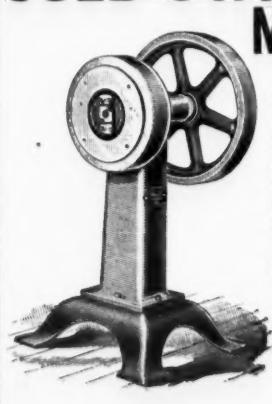

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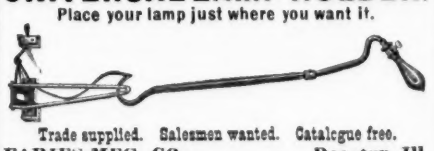

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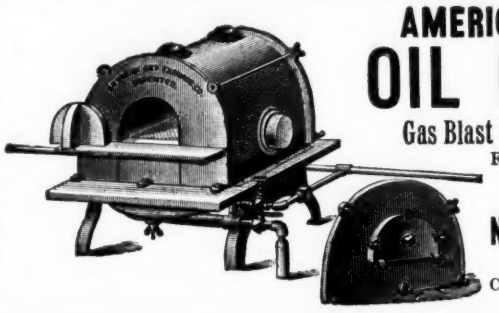

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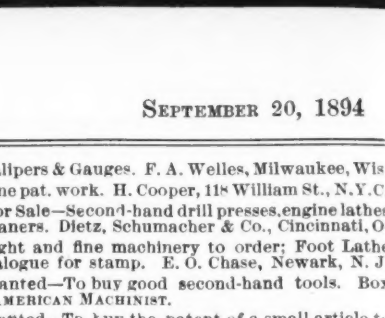

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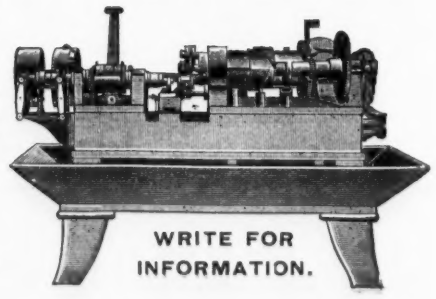

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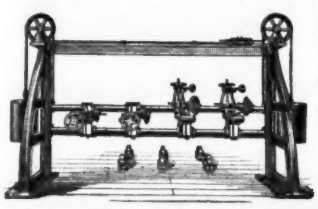

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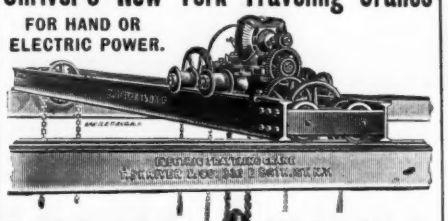

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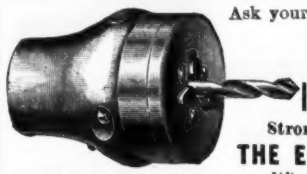

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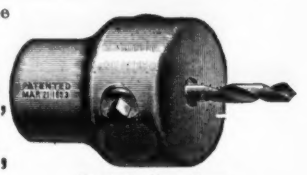

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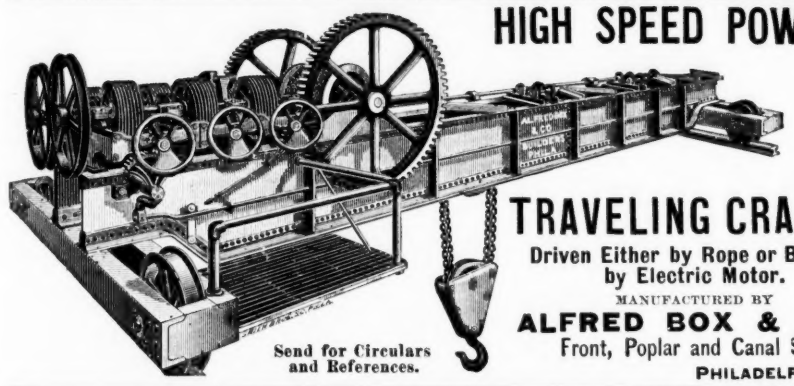

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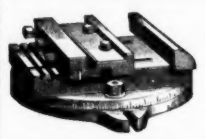

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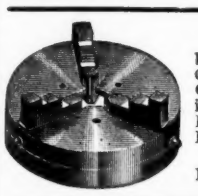

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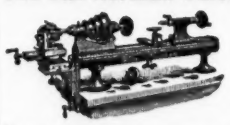

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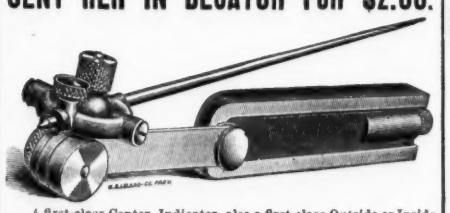

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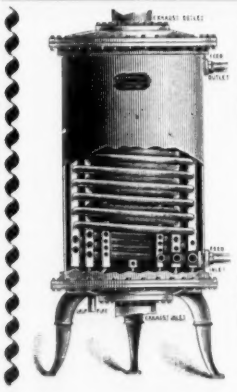

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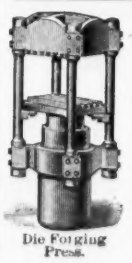

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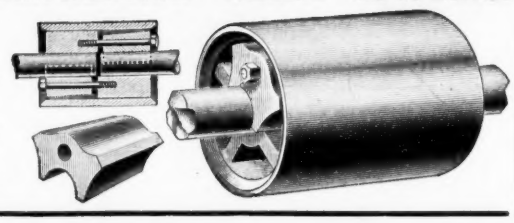

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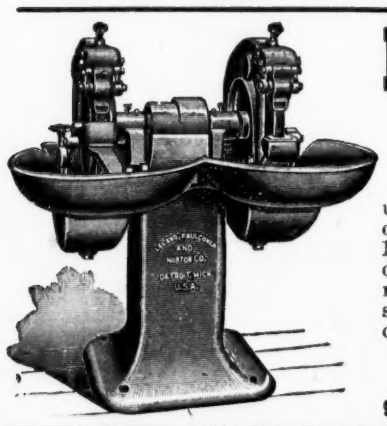

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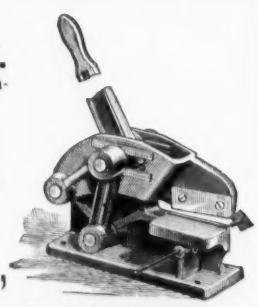

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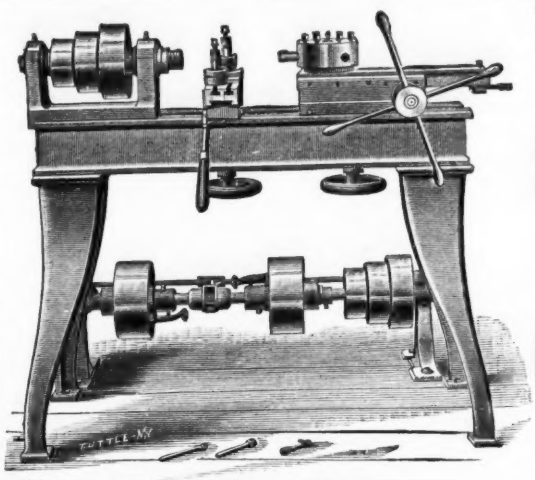

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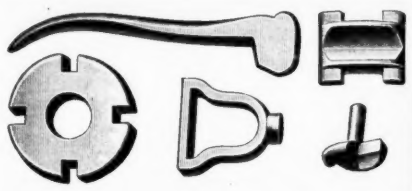

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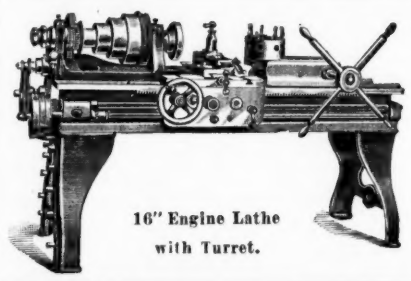

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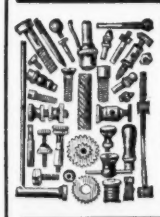

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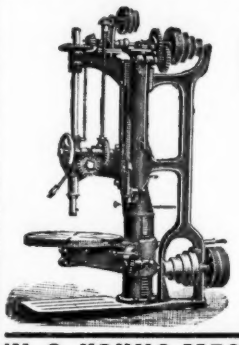

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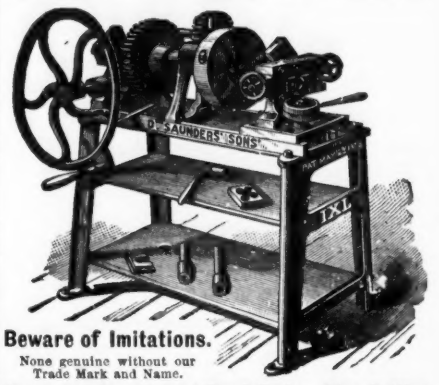

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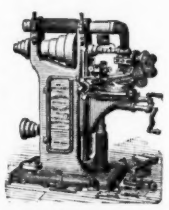

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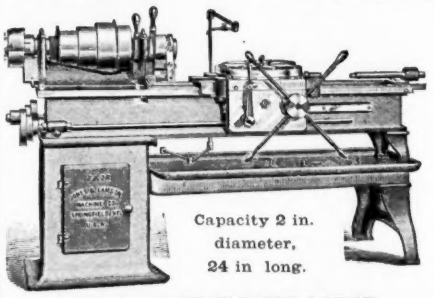

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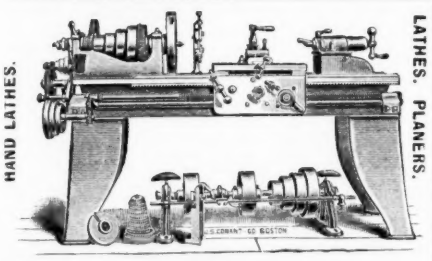

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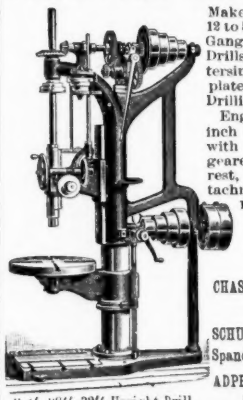

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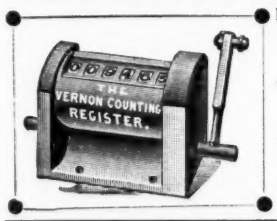

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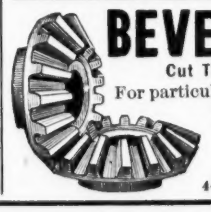

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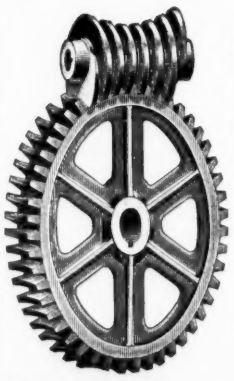

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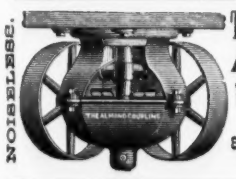

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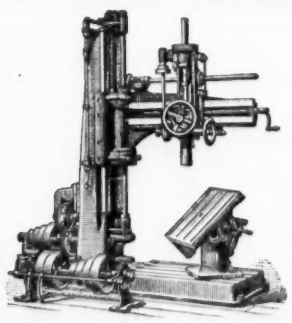

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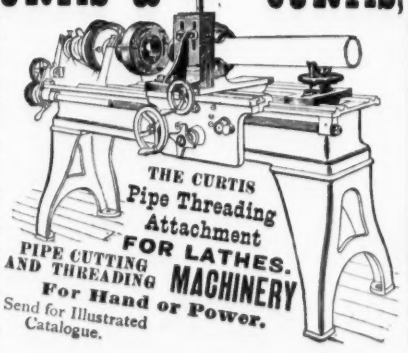

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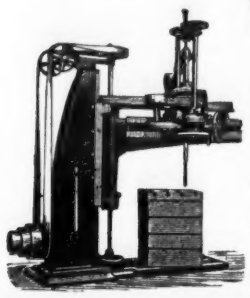

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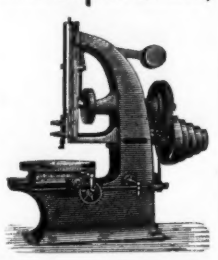

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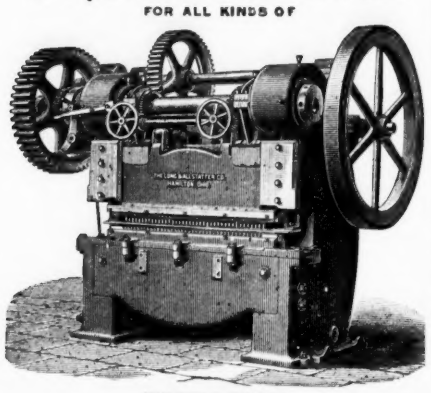

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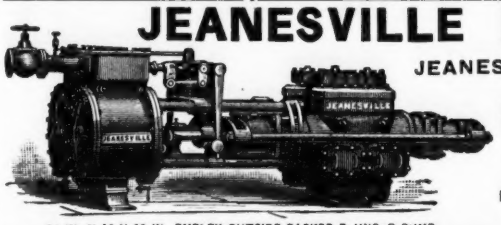

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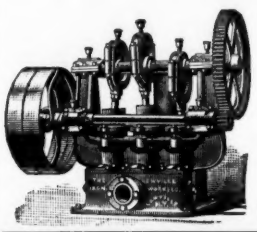

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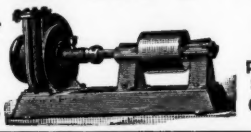

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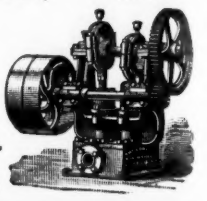

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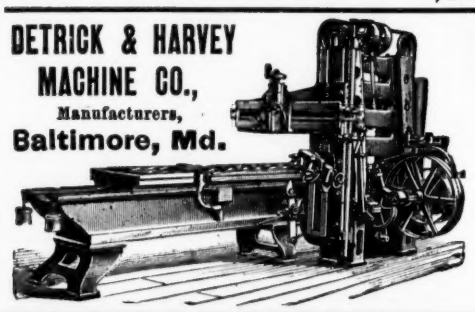

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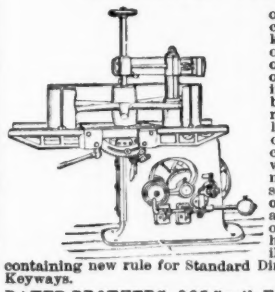

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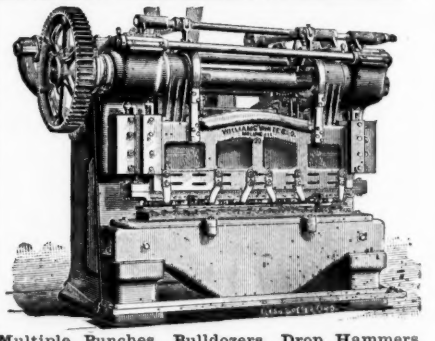

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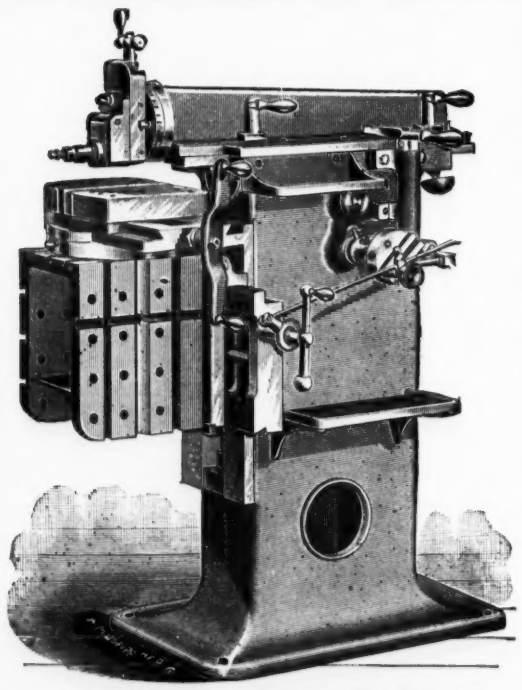

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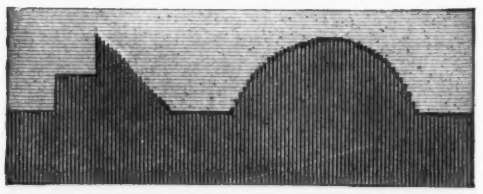

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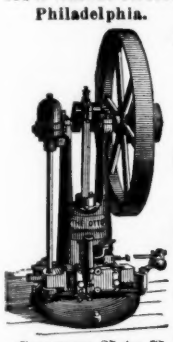

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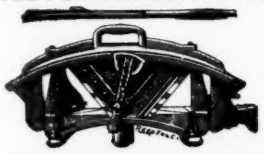

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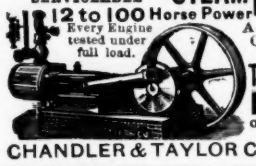

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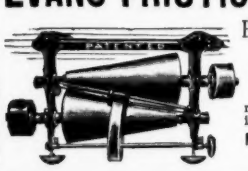

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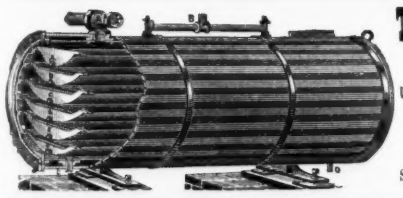

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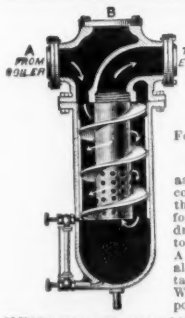

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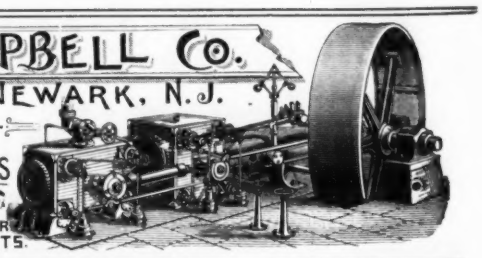

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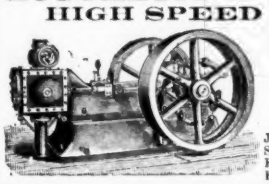

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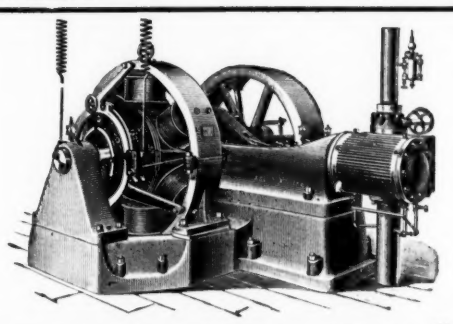

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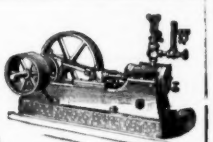

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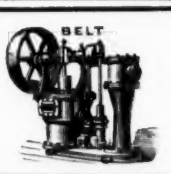

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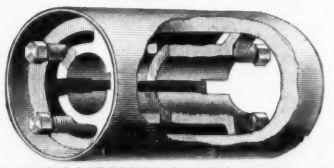

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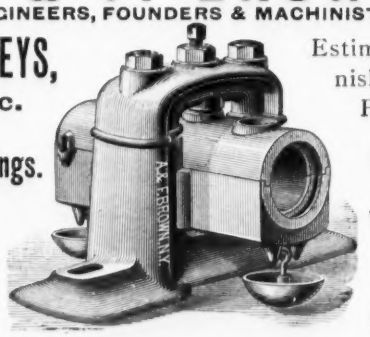

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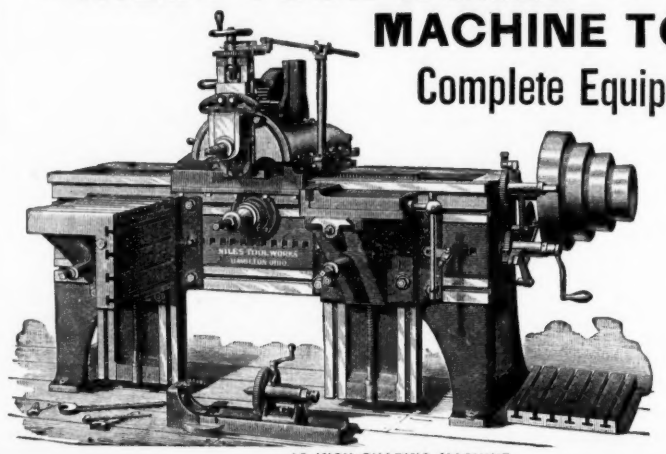

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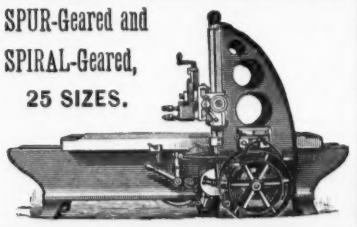

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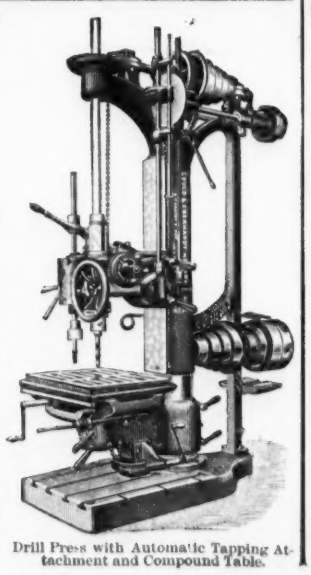

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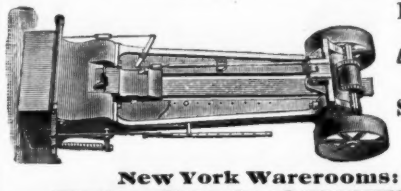

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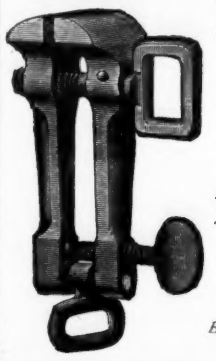

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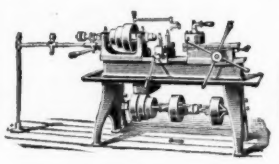

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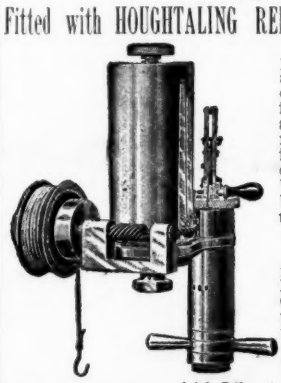

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